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TIMSS 2027

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ASSESSMENT FRAMEWORKS

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IEA TIMSS & PIRLS BOSTON COLLEGE

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Foreword

IEA (The International Association for the Evaluation of Educational Achievement) is an independent international cooperative with a network composed of national research institutions, governmental research agencies, distinguished scholars, and analysts from around the globe. Founded with the goal of improving education worldwide, IEA undertakes rigorous, high-quality, large-scale studies that offer deep insights into how students across different education systems are performing.

Our core mission is to enhance our understanding of educational policies, practices, and processes, contributing to the improvement of quality teaching and learning both within and across countries. IEA's studies provide essential information to educators, policymakers, and researchers, enabling meaningful insights and providing data for secondary research to enhance education worldwide.

TIMSS (Trends in International Mathematics and Science Study), conducted by IEA, is one of our flagship international assessments. Managed by IEA's TIMSS & PIRLS International Study Center at Boston College's Lynch School of Education and Human Development, TIMSS assesses the mathematics and science achievement of students at fourth and eighth grades around the world. Since its inception in 1995, TIMSS has provided countries with reliable, comparable data that highlight trends in educational outcomes, allowing for evidence-based reforms in mathematics and science instruction.

TIMSS offers participating countries a detailed picture of student performance in mathematics and science, and, through repeated cycles, provides trend data critical for evaluating the effectiveness of educational reforms and policy changes over time. The unique quasi-longitudinal design of TIMSS enables countries to monitor student cohorts from fourth grade through eighth grade, facilitating early interventions and adjustments to curricular policies when needed.

For over three decades, this large-scale international assessment has provided invaluable insights into mathematics and science education worldwide, offering educators and policymakers information to foster continuous improvement in educational outcomes. The release of the *TIMSS 2027 Assessment Frameworks* marks another milestone in the longstanding tradition of TIMSS and provides details on the content specifications and methodology shaping the next cycle of this flagship study.

Building on the successful transition to a fully digital assessment initiated in 2023, TIMSS 2027 advances our commitment to leveraging technology to enhance the efficiency of logistics and reporting while staying true to the standards of quality set forth by IEA's history in educational measurement. The assessment's adaptive digital design now integrates even more sophisticated and interactive items, enabling more precise measurement and engaging assessments tailored to a diverse global student population. These enhancements ensure that TIMSS remains a relevant and powerful tool for capturing nuanced insights into student achievement. The four chapters inside this framework highlight and contextualize many of these aspects.

The TIMSS 2027 mathematics and science frameworks for both fourth and eighth grades reflect the international collaboration of IEA's work, ensuring alignment with current curricular goals and global educational priorities. Across the various aspects of the assessment design process, we emphasize not only foundational mathematics skills but also mathematical reasoning, problem-solving capabilities, and real-world applications crucial to today's learning environments. Similarly, the science frameworks now comprehensively integrate environmental literacy, underscoring its importance in addressing global challenges and fostering informed citizenship.

The foundational work for TIMSS 2027 also deepens our understanding of the contexts surrounding student learning through enriched background questionnaires completed by students, parents, teachers, and school leaders. These questionnaires capture critical data attitudes towards mathematics and science, socioeconomic background, and aspects of school environment, but also digital technologies, including the use of artificial intelligence, family involvement in education, school leadership practices, and students' views on environmental issues. New topics will allow for richer insights into the learning environments that support student success.

This publication is made possible by the dedicated contributions of numerous experts and organizations around the world. Our appreciation goes to all of the staff of the TIMSS & PIRLS International Study Center at Boston College and across both IEA offices for their support and excellence in managing this extensive international effort. I further extend my gratitude to the authors of the assessment frameworks: Ray Philpot and Charlotte Aldrich for the Mathematics Assessment Framework; Berenice Michels and Allison Bookbinder for the Science Assessment Framework; Katherine Reynolds, Audrey Gallo, and Deepthi Kodamala for the Contextual Framework; and Liqun Yin and Eugenio Gonzalez for the Assessment Design. Their expertise and dedication have been instrumental in shaping this comprehensive information.

Special thanks are also due to the Science and Mathematics International Research Committee (SMIRC), the Questionnaire International Research Committee (QIRC), the TIMSS National Research Coordinators, and the countless educators and researchers whose collective input ensures the rigor and relevance of the frameworks.

Finally, I wish to acknowledge the support of the IEA member institutions, governmental bodies, and all participating countries. Their sustained commitment to educational excellence and international collaboration enables TIMSS to continue making meaningful contributions to global educational improvement.

With these frameworks, TIMSS 2027 is poised to deliver rich, actionable insights, helping education systems around the globe meet the evolving demands of teaching mathematics and science effectively in a rapidly changing world.

Dirk Hastedt
IEA Executive Director

Introduction to the TIMSS 2027 Assessment Frameworks:

Advancing Digital Assessment in Mathematics and Science

Matthias von Davier

TIMSS (Trends in International Mathematics and Science Study) is a long-standing international assessment of mathematics and science at the fourth and eighth grades, collecting trend data every four years since 1995. Over 70 countries rely on TIMSS to monitor their education systems in a global context, benchmarking national curricula and informing policy and practice. Building on the successful transition to digital assessment in 2023, TIMSS 2027 marks the second fully digital cycle, further harnessing technology to enhance data quality, improve operational efficiency, and strengthen the utility of results.

TIMSS uses the curriculum—broadly defined—as the foundation for understanding educational opportunities and outcomes across educational systems. The TIMSS Curriculum Model comprises three interconnected aspects: the intended, implemented, and attained curriculum. The intended curriculum encompasses contexts that include system-level policies, curricular standards, and organizational structures designed to facilitate learning. The implemented curriculum covers contexts surrounding the translation of curricula into practice, including instructional delivery, teacher practices, and home and school environments. The attained curriculum focuses on student achievement and attitudes toward mathematics and science. This model guides TIMSS in analyzing how educational systems shape student outcomes.

The TIMSS mathematics and science frameworks are updated with each assessment cycle through a collaborative, expert-driven process to ensure alignment with current educational objectives, practices, and priorities across participating countries. At the same time, frameworks retain key elements to ensure valid measurement of achievement trends across cycles. Updates for TIMSS 2027 mathematics and science frameworks also include descriptions of the TIMSS problem-solving and inquiry tasks (PSIs) integrated within the broader discussion of the cognitive domains. The assessment also integrates more complex, interactive item types to capture problem-solving approaches and processes. These innovations leverage expanded capabilities in automated scoring, including machine learning for both graphical and written responses.

The *TIMSS 2027 Mathematics Framework* presents the updated assessment frameworks for mathematics at the fourth and eighth grades. The framework specifies the content domains, including number, measurement and geometry, and data, and the target percentages of the assessment devoted to covering topics within each content domain. Cognitive domains—knowing, applying, and reasoning—evaluate students' conceptual understanding, problem-solving processes and skills, and analytical thinking. Newly developed items incorporate current curricular priorities in mathematics education, such as computational thinking, and a continued emphasis on real-world applications.

The TIMSS 2027 Science Framework, structured around the domains of biology, physical science, chemistry, and earth science, reflects current priorities in global science education. Like mathematics, the cognitive domains assess foundational knowledge, practical application, and higher-order reasoning. Updates focus on integrating environmental knowledge within specific topics from relevant content domains and incorporating existing science practices into the discussion of the cognitive domains.

The TIMSS 2027 Contextual Framework outlines the comprehensive system for collecting background data on policies, classroom practices, and student learning environments that support and characterize students' mathematics and science achievement. Student, parent, teacher, and school questionnaires cover students' attitudes and behaviors, home learning environments, classroom practices, and school climate. New scales address the use of digital devices and AI tools in education, family involvement in education, and school leadership practices. Also included is a description of the planned *TIMSS 2027 Encyclopedia*, which documents national policies and, mathematics and science curricula at the fourth and eighth grades, and teacher training, along with curriculum questionnaires providing standardized cross-country data on the organization of the education system, including the system for preprimary education, teacher and principal preparation, and curriculum specifications.

The TIMSS 2027 Assessment Design features an innovative, digitally enabled approach, building on the group adaptive design introduced in TIMSS 2023. The adaptive testing design incorporates easy, medium, and difficult blocks arranged into more and less difficult booklets. A new feature introduces performance-based routing after the first half of the assessment, allowing very low-performing students to receive easier second-half blocks. This approach aims to improve measurement precision at the lower end of the achievement scale, where previous cycles often proved too difficult to provide precise estimates. The TIMSS 2027 assessment also fully integrates interactive problem-solving and inquiry tasks, which include simulations, multimedia content, and innovative response formats. Leveraging the success of automated scoring in TIMSS 2023, the TIMSS 2027 assessment will include a higher proportion of automatically scored constructed-response items while following rigorous assessment design and block assembly guidelines for the fourth- and eighth-grade assessments. The key features of the TIMSS 2027 assessment design aim to optimize engagement, reduce measurement error, and ensure robust cross-country comparisons.

TIMSS 2027 builds on a strong tradition of providing assessments in mathematics and science at the fourth and eighth grades with updated content, an expanded use of digital tools, and an innovative test design. The frameworks reflect current educational priorities in mathematics while preserving the ability to report trends in student achievement. With enhanced item formats, adaptive testing, and enriched contextual questionnaires, TIMSS 2027 supports a comprehensive view of how educational systems prepare students to meet evolving curricular goals and instructional expectations around the world.

CHAPTER 1

TIMSS 2027 Mathematics Framework

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Overview

Mathematics is a crucial academic subject for students, as it is an important building block for future learning and professional skill development. All students can benefit from developing an understanding of and facility with mathematics. In the early stages, mathematics learning supports children's emergent curiosity about how the world around them operates. Further on in their education, mathematics is essential in navigating daily life, and mastery of mathematics skills is relevant in many career fields.

Learning mathematics helps develop highly transferable skills, such as adaptability and problem solving, that are paramount in our ever-changing world. Mathematics can be used to bolster artistry and creativity, to make technical plans to execute a design, and to investigate patterns of the natural world.[1,2,3] Mathematics education enhances creative thought and invites students to understand the world in a logical, structured way, which in turn supports learning in other subjects.[4] Developing mathematical skills can position students for long-term success along vocational and academic career paths.[5,6] Mathematics supports essential everyday activities and decision-making like managing finances, estimating distances, or understanding data.[7]

The TIMSS 2027 Mathematics Framework builds on TIMSS's 32-year history of assessments and describes the mathematics measured in the TIMSS fourth-grade and eighth-grade assessments. This chapter presents the assessment frameworks for the two TIMSS 2027 mathematics assessments in the fourth and eighth grades. In general, the fourth- and eighth-grade mathematics frameworks are similar to those used in TIMSS 2023. Each cycle incorporates updates into the assessment frameworks to reflect the evolution of participating countries' curricula, standards, and frameworks. Sources informing these updates include the detailed reporting of the *TIMSS 2023 Encyclopedia*,[8] input from the TIMSS 2027 Science and Mathematics International Research Committee (SMIRC), and suggestions from the TIMSS 2027 National Research Coordinators.

The TIMSS 2027 mathematics assessments are designed such that a certain proportion of each area defined in the assessment frameworks is represented among the set of items included in the assessment, as described in the following sections. The TIMSS Mathematics Framework defines both the *content domain*, describing the topics to be assessed, and the *cognitive domain*, outlining the cognitive processes needed to solve mathematics items correctly. This document defines those domains that are reported as subscales to overall TIMSS mathematics achievement.

The primary purpose of this chapter is to outline the content and cognitive domains that form the foundation for international comparisons in the TIMSS Mathematics assessments. The TIMSS 2027 Mathematics Framework informs all item development for the TIMSS 2027 mathematics assessments at fourth and eighth grade. Each item in the TIMSS mathematics assessments is designed to target only one content domain and one cognitive domain. The frameworks also discuss key aspects in mathematics education and assessment that influence decisions about the assessment content and specifications.

TIMSS Mathematics Content Domains

TIMSS assesses student knowledge in mathematics subject matter via the definition of the content domains at each grade. The coverage and definition of the mathematics content domains differ for the fourth and eighth grades, reflecting the mathematics widely taught at each grade and the development of topics covered across international mathematics curricula. Exhibit 1.1 shows the target percentage of item score points in the assessment for each content domain for the TIMSS 2027 fourth- and eighth- grade assessments.

Exhibit 1.1: Target Percentages of the TIMSS 2027 Mathematics Assessment Devoted to Content Domains at the Fourth and Eighth Grades

Fourth Grade

Content Domains	Percentages
Number	50%
Measurement and Geometry	30%
Data	20%

Eighth Grade

Content Domains	Percentages
Number	30%
Algebra	30%
Geometry and Measurement	20%
Data and Probability	20%

Each content domain consists of at least one *topic area*, and each topic area, in turn, includes several *topics*. The framework for each grade has 20 topics comprising approximately 5 percent of the assessment overall. Accordingly, each topic receives approximately equal weight in score points across the items developed to measure them at each grade of the mathematics assessments.

In the fourth-grade mathematics assessment, there is more emphasis on topics in the number content domain than in either of the other two domains, reflecting similar curricular emphases internationally. Moving to the eighth grade, algebra is added as a content domain to match the mathematics curricula at that grade level internationally. The introductory algebraic topics assessed at the fourth grade (sometimes referred to as pre-algebra) are included in the number content domain. Both measurement and geometry are included in both grades, but at the fourth grade, measurement is the primary focus of the domain, with only a preliminary understanding of geometric shapes required. In contrast, the eighth-grade geometry and measurement domain emphasize purely geometric topics. The fourth-grade data domain focuses on reading, representing, and interpreting data in a defined set of representations, whereas at the eighth grade, the data and probability domain emphasizes drawing conclusions from data, basic statistics, and the fundamentals of probability.

TIMSS Mathematics Cognitive Domains

In understanding mathematics, students need to know the mathematics content being assessed and must also draw on a range of cognitive skills. Numerous theories map the progression of students' cognition through childhood development broadly (e.g., Piaget, 1970) and and conceptual frameworks articulate objectives for learning (e.g., Krathwohl, 2002; Bloom, 1956).[9,10,11] Generally, the cognitive skills understood to underlie mastery of subject matter follow the progression from developing a knowledge base, to engaging that knowledge in unfamiliar contexts, and to making judgments or justifying arguments.[12,13]

In the TIMSS assessments, these sets of cognitive skills are referred to as cognitive domains and three domains have been identified: *knowing*, *applying*, and *reasoning*. The first domain, knowing, covers the recollection of facts or concepts and the execution of routine procedures. The applying domain focuses on applying factual and procedural knowledge and conceptual understanding in a range of situations. The reasoning domain involves the logical, systematic thinking students need to use to justify solutions to problems, make inferences, and understand the connections across mathematical concepts. TIMSS cognitive domains can be related to Bloom's taxonomy of educational objectives and its later revision.[14]

Briefly, remembering and understanding processes map to knowing; applying remains applying; and analyzing, evaluating, and creating (which refers to synthesizing knowledge and skills to generate something new) can be found in the reasoning domain. These cognitive processes are understood to build on each other and are frequently depicted as a pyramid of increasingly more challenging processes. Across the three cognitive domains of TIMSS mathematics, items requiring the 1) knowing, 2) applying, and 3) reasoning also present as, on average, increasingly difficult sets of tasks.

Exhibit 1.2 shows the target percentage of item score points in the assessment for each of the three cognitive domains at the fourth and eighth grades. Reflecting the development in skills and differences in the ages of students, the balance of score points differs between these grades.

Exhibit 1.2: Target Percentages of the TIMSS 2027 Mathematics Assessment Devoted to Cognitive Domains at the Fourth and Eighth Grades

Cognitive Domains	Fourth Grade	Eighth Grade
Knowing	40%	35%
Applying	40%	40%
Reasoning	40%	25%

Students exercise knowing, applying, and reasoning to varying extents when engaging in mathematical thinking. Identifying these skills is crucial in developing an assessment like TIMSS 2027, ensuring that the survey covers the appropriate range of cognitive skills across the content domains. Each TIMSS mathematics item is classified according to the primary cognitive process students access when responding correctly to the item. Content and cognitive skills are cross-classified; each item belongs to one content and one cognitive domain.

Problem Solving and Problem Contexts in TIMSS Mathematics

Problem solving is an overarching process of TIMSS mathematics carried out across the content domains. In general, "problem solving refers to cognitive processing directed at achieving a goal when the problem solver does not initially know a solution method."[15] Specifically for mathematics, problem solving can take place in a real-world context or in purely mathematical terms.[16]

Mathematical problems set in a real-world context can be addressed using a modeling cycle: First, the problem is translated from the real world into mathematical representations; then, mathematical knowledge, procedures, and reasoning are applied to those representations to produce a mathematical solution or explanation; finally, the solution or explanation is translated back to the real world and interpreted and validated.[17,18] If the original problem has not been solved, the cycle might need to be repeated with revised assumptions.

Within the scope of the TIMSS mathematics assessments, the processes involved in solving a mathematics problem are described in the TIMSS cognitive domains, where each item targets a single process defined therein. Every mathematics item in TIMSS is assigned one cognitive area within the three cognitive domains: knowing, applying, or reasoning. Individual items in TIMSS cannot prompt students to engage in the entire modeling cycle, but the collection of items included in TIMSS covers the range of cognitive skills in which students engage while moving through a full modeling cycle. Any single cognitive skill involved in the process of solving a problem can be included in any content domain by targeting the appropriate cognitive area within one of these cognitive domains. For instance, the cognitive domain *applying* defines the cognitive area *formulate*, which includes determining appropriate operations and instructions to address a problem; or the cognitive domain *knowing* defines the cognitive area *compute*, which includes using (known) algorithmic procedures to find a result.

In TIMSS items and in problem solving generally, the extent of familiarity with the problem context can contribute to the complexity of cognitive engagement required to successfully navigate all or part of the modeling cycle. Contexts can be immediately familiar or can require some decoding, and the complexity of the decoding effort depends on the intended audience for the problem. For example, an item asking fourth-grade students to make the largest possible even number using a set of number cards would likely require substantial cognitive processing for that grade level to achieve the goal. Thus, the item poses a more complex problem for these students and would engage higher-order cognitive skills. The same item might not constitute a problem for students in eighth grade since the cognitive processes that they might need to draw on are simpler, possibly more automatic recall of relevant number facts.

For TIMSS mathematics, approximately 85 percent of items will be situated in a context; most of these will be suitable for problem solving by students at the appropriate grade level. Nonetheless, items without a real-world context can still be suitable for problem solving if they are non-routine for the student attempting them. The remaining 15 percent of the items in TIMSS mathematics will be presented without context, such that the possible effects of reading load do not affect students' ability to display their skills and knowledge.

Among the items situated within real-world contexts in TIMSS are Problem-Solving and Inquiry tasks (PSIs), offering extended measurement of problem solving by including multiple steps of problem solving and higher-order cognitive skills across several items situated within more complex scenarios. PSIs comprise independent items that are still individually assigned to one content and cognitive domain per item as defined in this framework. However, the PSIs establish a way to assess these domains more deeply and authentically, relying on the shared context across items to guide students through multiple stages of the modeling cycle throughout the task. This prepares students to engage with more complex scenarios and contexts than could be achieved in a single TIMSS item. Further information on the characteristics of PSIs can be found in the TIMSS 2027 Guidelines for Developing PSIs.[19]

TIMSS 2027 Mathematics Content Domains—Fourth Grade

Three major content domains define the mathematics content for the TIMSS Mathematics fourth-grade assessment: number, measurement and geometry, and data. Whole numbers are the predominant component of the number domain; students at the fourth grade compute with whole numbers of reasonable size. Fourth-grade students work with familiar objects and understand the relationships between shapes and sizes. Students at the fourth grade manipulate data to read and create basic data displays and make comparisons between different representations of the same data or between different datasets.

Number

The number content domain consists of three topic areas such that the 50 percent of the assessment devoted to number is apportioned as follows:

- Whole numbers (25%)
- Expressions, simple equations, and relationships (15%)
- Fractions and decimals (10%)

Learning about whole numbers provides the foundation of mathematics in primary school. Introductory algebraic concepts are also part of the TIMSS assessment at the fourth grade, including understanding the use of unknowns in simple equations and an initial understanding of variables and relationships between quantities. However, because quantities and measures of object properties often do not come in whole numbers, it is also important for students to understand fractions and decimals.

Whole Numbers

1. Connect representations (i.e., words, symbols, and models including number lines), compare numbers up to 6 digits, and understand place value.
2. Add and subtract up to 4-digit numbers.
3. Multiply (up to 3-digit by 1-digit and 2-digit by 2-digit numbers) and divide (up to 3-digit by 1-digit numbers), including with a remainder.
4. Understand and use odd and even numbers, multiples and factors of numbers, round numbers (up to the nearest powers of 10), and make estimates.
5. Combine two or more properties of numbers (e.g., place value, odd/even) or arithmetic operations (e.g., double and add 5).

Expressions, Simple Equations, and Relationships

1. Find the missing number or operation in a number sentence (e.g., 17 + ■ = 29).
2. Match or write expressions or number sentences to represent problem situations that may involve unknowns.
3. Match, describe, or use relationships between numbers in a well-defined pattern (e.g., describe the relationship between adjacent terms of a sequence and generate whole numbers given a rule).

Fractions and Decimals

1. Describe a fraction as part of a whole or collection; connect different representations of fractions (i.e., words, numbers, and models); compare fractions including with different denominators; add and subtract simple fractions with the same denominators of 2, 3, 4, 5, 6, 8, 10, 12, or 100.
2. Connect different representations of decimals (i.e., words, numbers, and models); compare decimals and relate decimals to fractions; add and subtract decimals (up to two decimal places).

Measurement and Geometry

The two topic areas in measurement and geometry are as follows:

- Measurement (15%)
- Geometry (15%)

In primary school, measurement—the process of quantifying attributes of objects and phenomena—introduces performing basic calculations with length, mass, volume, and time, and using a ruler to measure length (standardized 10-centimeter onscreen ruler with millimeter gradation, which includes rotation and drag functionality). Spatial sense is integral to the study of geometry, and students analyze geometric relationships and use these relationships to draw conclusions about a variety of two-dimensional shapes and three-dimensional objects.

Measurement

1. Measure, estimate, add, and subtract lengths (e.g., millimeters, centimeters, meters, kilometers).
2. Add and subtract mass (e.g., grams and kilograms), volume (e.g., milliliters and liters), and time (e.g., minutes and hours); select appropriate types and sizes of units and read scales.
3. Determine perimeters of polygons, areas of rectangles, areas of shapes covered with squares or partial squares, and volumes filled with cubes.

Geometry

1. Recognize and draw parallel and perpendicular lines, right angles, and angles smaller or larger than a right angle; compare the relative size of angles.
2. Use elementary properties, including line symmetry, to describe and create common two-dimensional shapes (i.e., circles, triangles, quadrilaterals, and other polygons).
3. Use elementary properties to describe three-dimensional objects (i.e., cubes, rectangular solids, cones, cylinders, and spheres) and how they relate to their two-dimensional representations.

Data

The data content domain consists of two topic areas:

- Single dataset (15%)
- Multiple datasets (5%)

The widespread availability of data in today's information society has resulted in various visual displays of quantitative information, also commonly referred to as (data) visualizations. Thus, students need to understand that graphs and charts help organize information or categories and provide a way to compare data. At the fourth grade, students primarily interact with representations of single datasets, but they also begin to work with data from one or more sources.

Single Datasets

1. Read data from tables, pictographs, bar graphs, line graphs, and pie charts.
2. Create or complete tables, pictographs, bar graphs, line graphs, and pie charts.
3. Compare different representations of the same dataset.

Multiple Datasets

1. Combine or compare representations of two or more datasets.

TIMSS 2027 Mathematics Content Domains—Eighth Grade

Four content domains define the mathematics content for the TIMSS Mathematics eighth-grade assessment: number, algebra, geometry and measurement, and data and probability. Building on the number content domain at the fourth grade, eighth-grade students develop proficiency with more advanced whole number concepts and procedures and extend their mathematical understanding of rational numbers presented in various forms (integers, fractions, and decimals). With the introduction of algebra, students engage with patterns and relationships more formally with variables and functions. Extending their understanding of shapes and measures assessed at the fourth grade, eighth-grade students analyze the properties of a variety of two-dimensional shapes and three-dimensional objects and calculate perimeters, areas, and volumes. Eighth-grade students can read and extract meaning from a variety of displays and visualizations, begin to understand basic statistics, and start to work with probability.

Calculator Use at the Eighth Grade

At the eighth grade, students will be permitted to use the TIMSS on-screen calculator that is available for every item in the eighth-grade assessment. This calculator includes the four basic operations (+, –, ×, ÷), a square root key, and the negative sign. Students will not be permitted to bring their own calculators. The calculator executes one calculation at a time and does not include more advanced features such as graphing. Overall, the mathematics items are developed to be calculator-neutral and do not have advantages or disadvantage for students whether or not they use calculators. A notable exception is the (very few) items that require taking a square root, mainly in applications of the Pythagorean Theorem.

Number

At the eighth grade, the 30 percent of the assessment devoted to number consists of three topic areas:

- Integers (10%)
- Fractions and decimals (10%)
- Proportions, ratios, and percentages (10%)

In eighth grade, students need to compute with integers as well as fractions and decimals, and understand quantities represented in different forms. A single rational number can be represented with many different written symbols, and it is important that students can translate these representations to recognize the distinctions among interpretations of rational numbers, convert between them, and reason with them. This includes the facility to apply proportions, ratios, and percentages to whole numbers.

Integers

1. Recognize and use properties of numbers and operations; find and use multiples and factors, recognize prime numbers, and evaluate positive integer powers of numbers and square roots resulting in integers.

    Note: In other content domains (e.g., geometry), square roots may involve integers beyond perfect squares.

2. Add and subtract positive and negative numbers, including through movement and position on a number line or using various models (e.g., thermometers, losses and gains).

Fractions and Decimals

1. Using various models and representations, compare fractions and decimals, identify equivalent fractions and decimals, and round decimals.
2. Add, subtract, and multiply with fractions and decimals, and divide fractions and decimals by a whole number.

Proportions, Ratios, and Percentages

1. Determine proportions and ratios of quantities (e.g., rates, scales on maps, recipes).
2. Apply or find percentages; convert between percentages and fractions or decimals.

Algebra

The 30 percent of the assessment devoted to algebra is comprised of two topic areas:

- Expressions, operations, and equations (20%)
- Relationships and functions (10%)

The introduction of algebra is a major milestone in mathematics education—using algebraic models and expressing relationships algebraically, rearranging formulas, and substituting values into formulas. Conceptual understanding of such models and relationships can extend to linear and simple nonlinear functions to describe what will happen to one variable when a related variable changes.

Expressions, Operations, and Equations

1. Find the value of an expression or a formula given the values of the variables.
2. Simplify algebraic expressions involving sums, products, differences, and positive integer powers; compare expressions to decide if they are equivalent.
3. Write expressions, equations, or inequalities to represent problem situations.
4. Solve (or validate potential solutions to) linear equations; solve simple linear inequalities and simple simultaneous linear equations in two variables, including validating values as solutions.

Relationships and Functions

1. Interpret, relate, and generate representations of linear functions in tables, graphs, or words; recognize properties of linear functions, including slope and intercepts; generalize linear patterns or sequences using words or algebraic expressions.
2. Interpret, relate, and generate representations of simple nonlinear functions (e.g., quadratic) in tables, graphs, or words; and generalize nonlinear patterns or sequences using words or algebraic expressions.

Geometry and Measurement

The geometry and measurement content domain at the eighth grade consists of one topic area:

- Geometry and Measurement (20%)

At the eighth grade, students can relate and integrate representations of three-dimensional objects and apply that understanding to composites of known shapes. Students are able to apply their understanding of geometric relationships to plotting on the Cartesian plane. They can explain geometric relationships, such as congruence, similarity, and the Pythagorean Theorem.

Geometry and Measurement

1. Recognize and draw types of angles and pairs of lines and use the relationships between angles on lines and in geometric figures, including those involving the measures of angles and line segments; read and plot points in the Cartesian plane.
2. Recognize two-dimensional shapes and use their geometric properties (e.g., sums of interior angles of triangles and quadrilaterals, properties of isosceles triangles), including calculating length and area, and use the Pythagorean Theorem.

   Note: Two-dimensional shapes include (or can be composed of) circles; scalene, isosceles, equilateral, and right-angled triangles; trapezoids, parallelograms, rectangles, rhombuses, and other quadrilaterals; as well as other polygons including pentagons, hexagons, octagons, and decagons.
3. Determine the results of geometric transformations (i.e., translations, reflections, and rotations) in the plane; recognize and use properties of congruent and similar triangles and rectangles.
4. Recognize three-dimensional objects and use their properties to calculate surface area and volume; relate three-dimensional objects with their two-dimensional representations.

   Note: Three-dimensional objects include (or can be composed of) prisms, pyramids, cones, cylinders, and spheres.

Data and Probability

The data and probability content domain contains two topic areas:

- Data (15%)
- Probability (5%)

Increasingly, students encounter data in formats beyond the more traditional forms of data display (e.g., bar graphs, line graphs, pie graphs, pictographs)—information is being supplemented by an array of new graphic forms (e.g., infographics). Thus, students must extend their understanding of how to read, understand, organize, and represent data to being familiar with the statistics underlying data distributions and how these relate to the shape of data graphs. Students build on knowledge of organizing and representing data to make predictions and projections beyond what is represented. Students in eighth grade also have an initial grasp of some probability-related concepts.

Data

1. Organize and represent data in histograms, dot plots, scatter plots, clustered and stacked bar charts, and infographics, in addition to representations included at fourth grade (i.e., tables, pictographs, bar graphs, line graphs, and pie charts).
2. Interpret data from one or more sources, including making inferences, interpolating and extrapolating, and modeling (e.g., trends, predictions, productivity).
3. Summarize data distributions; calculate, use, or interpret mean and median; recognize the effect of spread and outliers.

Probability

1. Determine theoretical probability based on proportions of favorable outcomes (e.g., rolling a fair die or drawing marbles of a particular color from a bag); estimate empirical probability based on experimental outcomes.

TIMSS 2027 Mathematics Cognitive Domains—Fourth and Eighth Grades

For the fourth- and eighth-grade TIMSS assessments, each content domain includes items developed to address the three cognitive domains: knowing, applying, and reasoning. The following sections further describe the thinking processes that define these cognitive domains.

Each cognitive domain consists of a set of cognitive areas reflecting the cognitive processes defining that domain, elaborated by a brief description. Each TIMSS item is designed to target exactly one of these cognitive areas to ensure a range of coverage within each cognitive domain. There are no specified targets for the percentages of score points for each cognitive area across the TIMSS assessments.

Knowing

Facility in factual, conceptual, and procedural knowledge of mathematics forms the basis for applying mathematics or reasoning about mathematical situations.[20] Facts encompass the knowledge that provides the basic language of mathematics and the essential mathematical concepts and properties foundational for mathematical thought. Students access knowledge of relationships and representations, conventions and properties of numbers, symbolic representations, and spatial relations to engage in purposeful mathematical thinking. Procedures such as classifying or recognizing calculations and algorithms form the foundation of mathematics needed for solving problems encountered in daily life. The four cognitive areas included in knowing, form the foundation of mathematical fluency at both grades assessed in TIMSS.

Recall	Recall definitions, terminology, number properties, units of measurement, geometric properties, and notation (e.g., $a \times b = ab$, $a + a + a = 3a$).
Identify	Identify numbers, expressions, quantities, and shapes. Recognize when entities are mathematically equivalent. Read information from graphs, tables, texts, or other sources.
Order	Order and classify numbers, expressions, quantities, and shapes by common properties.
Compute	Compute arithmetic operations with whole numbers, fractions, decimals, and integers using algorithmic procedures. Carry out straightforward algebraic manipulation.

Applying

From a solid basis of knowledge, students can plan and execute to solve non-routine problems. As part of the problem-solving process, students may need to formulate the problem in mathematical terms, implementing a strategy to apply mathematical knowledge. Students will need to select suitable operations, strategies, and tools for solving problems. Ultimately, representing ideas or solutions forms the core of mathematical thinking and communication, and the ability to create representations is fundamental to success in the subject. The three cognitive areas of the applying domain involve the application of mathematics in a range of situations.

Formulate	Determine efficient/appropriate operations, instructions, programs, strategies, and sequences thereof for solving problems.
Implement	Implement suitable strategies, operations, or tools to produce solutions to problems.
Represent	Represent data in tables or graphs; create equations, inequalities, geometric figures, or diagrams that model problem situations; and generate equivalent representations for a given mathematical entity or relationship.

Reasoning

Reasoning mathematically involves logical, systematic thinking through observing and finding patterns and relationships and making conjectures. It also involves making logical deductions based on specific assumptions and rules and justifying results. Evidence of reasoning processes can be found in explaining or justifying a solution method, making valid inferences based on information and evidence, or generalizing mathematical relationships. Each of the four cognitive skills listed in the reasoning domain may be drawn on when solving problems in less familiar contexts or when integrating several concepts or strategies. These skills support the basis of computational thinking (decomposition, pattern recognition, abstraction, and algorithm development).

Analyze	Decompose a problem; evaluate, describe, or use relationships among numbers, expressions, quantities, and shapes.
Integrate	Link different elements of knowledge, related representations, and procedures.
Generalize	Make statements that represent relationships in more general and more widely applicable terms.
Justify	Provide mathematical arguments to support a strategy or solution.

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CHAPTER 2

TIMSS 2027 Science Framework

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Overview

Science and technology constantly shape and reshape our daily lives: the food we eat, the air we breathe, our healthcare, communications, transportation, and more. Events like the COVID-19 pandemic and global climate change highlight the importance of scientific research in addressing problems with widespread societal impact. To understand and make informed decisions about these issues, we need to develop scientific literacy through science education that fosters analytical thinking and reasoning skills.

Scientific literacy empowers individuals to approach everyday situations and tackle important issues with critical thinking, problem-solving, and observational skills.[1] It aids them in distinguishing scientific knowledge from misinformation, and in making sound decisions that affect their own and others' health, society, the economy, and the environment.[2,3] For example, as new technologies emerge (e.g., artificial intelligence), scientific literacy can help individuals critically engage with these technologies, evaluating potential risks and benefits, reflecting on ethical implications, and participating in conversations about their societal influence.

In addition, there is an increased demand across the world for qualified professionals to pursue careers in science, technology, and engineering. Their knowledge and skills are needed to drive the innovation necessary to solve global societal and environmental problems, grow economies, and improve quality of life. To meet this demand, it is increasingly important that educators equip all students with an understanding of current scientific challenges and encourage more of them to consider advanced studies in science and related fields.

Science education in the primary grades capitalizes on young students' curiosity and starts them on a path of systematic inquiry about the world in which they live. As their understanding of science develops, students in the lower secondary grades can increasingly make informed decisions about themselves and their world so that, as adults, they can become informed and scientifically literate citizens[4] and decide whether to pursue a career in science and technology.

This philosophy towards science education forms the basis of this framework by defining the science knowledge, skills, and ways of thinking measured by the TIMSS assessment. The TIMSS 2027 Science Framework builds on TIMSS's 32-year history of assessments and describes the science measured in the fourth- and eighth-grade assessments. This chapter presents the assessment frameworks for the two TIMSS 2027 science assessments:

- TIMSS Science—Fourth Grade
- TIMSS Science—Eighth Grade

The TIMSS 2027 science frameworks are based on those underlying TIMSS 2023. However, there have been updates to reflect countries' evolving science curricula and learning goals as reported in the *TIMSS 2023 Encyclopedia*[5] and to reflect current best practices in science education and assessment. Namely, the TIMSS 2027 science frameworks incorporate the following changes from the TIMSS 2023 science frameworks:

- Environmental knowledge has been made a distinct subscale, drawing on specific topics from the biology and earth science content domains in the TIMSS science frameworks that measure students' understanding of environmental concepts.
- The topics of the fourth- and eighth-grade science frameworks align more clearly, showing the expected progression of students' scientific understanding between the grade levels.
- The percentage of items in the fourth-grade assessment devoted to knowing cognitive processes decreased to increase emphasis on engagement in science practices through investigations that require reasoning and applying knowledge and skills.
- The existing science practices are incorporated explicitly into the cognitive processes described within the cognitive domain of the science frameworks.

Domains of the TIMSS Science Frameworks

At each grade, the science assessment frameworks for TIMSS 2027 are organized around:

- *Content domains*, specifying the subject matter to be assessed
- *Cognitive domains*, specifying the thinking processes to be assessed[6]

The content and cognitive domains are described in more detail in the following sections.

TIMSS Science Content Domains

The TIMSS 2027 science frameworks define scientific literacy as including distinct content domains for both grades. The content domains differ for the fourth and eighth grades, reflecting the composition of each grade's curriculum. There is more emphasis on biology compared to physical science at the fourth grade than at the eighth grade. At the eighth grade, physics and chemistry are assessed as separate content domains and receive more emphasis than at the fourth grade, where they are assessed as one content domain (physical science). The earth science content domain has the same relative emphasis at both grades. Across all content domains, the objectives at the eighth grade are more sophisticated than at the fourth grade. To respond to TIMSS science items, students must have basic, grade-appropriate knowledge of scientific vocabulary, symbols, abbreviations, units, and scales.

While the TIMSS science assessment frameworks define distinct content domains, the nature of scientific knowledge is fundamentally interdisciplinary. There is overlap among scientific fields; therefore, knowledge from multiple disciplines is frequently required to answer scientific questions and solve problems. However, the technical distinction between content domains in TIMSS is necessary to facilitate an analysis that allows reporting an overall science achievement score and reporting achievement separately in content domains. For that reason, although some of the content objectives in the science frameworks incorporate concepts that cross multiple content domains, within the frameworks, these interdisciplinary concepts are assigned to one objective in one content domain. Compare, for example, the content objective, "*Describe how similarities and differences among living species and fossils provide evidence of the changes that occur in living things over time, and recognize that the degree of similarity of characteristics provides evidence of common ancestry*" with the objective, "*Recognize that some remains (fossils) of animals and plants that lived on Earth a long time ago are found in rocks and ice and make simple deductions about changes in Earth's surface from the location of these remains*." Both objectives require knowledge of the concept of fossils, but the first is classified as a biology topic related to diversity, adaptation, and natural selection, while the second is classified as an earth science topic, related to Earth's history. Therefore, items in TIMSS that ask about fossils contribute to either the biology or earth science content domain, depending on the specific knowledge that is asked of students.

Additionally, the following describes how science topics are organized within the TIMSS science content domains and how objectives are aligned with specific targets of measurement:

- Each content domain within the frameworks includes several major *topic areas*, and each topic area, in turn, includes one or more *topics*. Each topic is further described by specific *objectives* representing the students' expected factual knowledge and procedural knowledge or skills[7,8] assessed within each topic.[a]
- When interpreting the objectives, the following information is relevant: The verbs used in the objectives are intended to represent average, typical performances expected of a fourth- or eighth-grade student but are not intended to limit performances to a particular cognitive domain. Each objective can be assessed by drawing on any of the three cognitive domains (knowing, applying, and reasoning).
- Some objectives include additional parenthetical information. Illustrative examples appear after an "e.g.," such as in "*Recognize, compare, and contrast the life cycles of common animals (e.g., humans, frogs, butterflies)*." In other cases, the additional information is meant to restrict the scope of the objective to content appropriate for the students in the fourth or eighth grade. In that case, it appears after an "i.e.," such as in "*Recognize that matter can be changed from one state to another by heating or cooling; describe changes in the state of water (i.e., melting, freezing, evaporation, and condensation)*."

a The TIMSS 2027 science frameworks have an additional level of organization compared with the mathematics framework, which is organized into content domains, topic areas, and topics.

Across the fourth- and eighth-grade assessments, each content objective receives approximately equal weight regarding the number of score points. Exhibit 2.1 shows the target percentage of item score points in the assessment for each content domain for the TIMSS 2027 fourth- and eighth-grade assessments.

Exhibit 2.1: Target Percentages of the TIMSS 2027 Science Assessment Devoted to Each Content Domain at the Fourth and Eighth Grades

Fourth Grade

Content Domains	Percentages
Biology	45%
Physical Science	35%
Earth Science	20%

Eighth Grade

Content Domains	Percentages
Biology	35%
Chemistry	20%
Physics	25%
Earth Science	20%

Environmental Knowledge in TIMSS 2027

In TIMSS 2027, *environmental knowledge* is reported as an additional subscale comprising science items from the biology and earth science content domains. The objectives within the TIMSS 2027 Science content domains for the fourth and eighth grades selected to contribute to the environmental knowledge subscale have been marked with an asterisk. Approximately 25 percent of science items at both grades measure environmental knowledge while also belonging to the biology and earth science domains. A more detailed definition of environmental knowledge at both grades is provided in a later section.

TIMSS Science Cognitive Domains

Understanding science is not only having knowledge of science concepts and procedural knowledge of science skills, but also applying scientific ways of thinking and actively engaging in science practices.[9] One aspect cannot be separated from the other two; that is, knowledge is needed to engage in scientific thinking and practices, and vice versa. Current science curricula reflect standards for multiple aspects of science learning,[10,11,12] such as practices and knowledge. While the content domains in TIMSS cover scientific and procedural knowledge, the cognitive domains encompass the cognitive processes involved in scientific ways of thinking and using scientific practices to investigate the natural world. The content and cognitive domains define scientific knowledge and what students are asked to do with this knowledge.[13]

In the TIMSS assessments, three cognitive domains describe the thinking processes and science practices students are expected to engage in when encountering the science items developed for TIMSS 2027: *knowing*, *applying*, and *reasoning*. The three cognitive domains are the same at both grades, reflecting a progression from developing knowledge of scientific concepts to applying that knowledge and, finally, reasoning with conceptual understandings and evidence or data.[14,15] The first domain, knowing, covers the recollection of facts, concepts, and procedures that are necessary for a solid foundation in science. The second domain, applying, focuses on applying conceptual and procedural knowledge in various situations. The third domain, reasoning, involves using evidence and systematic thinking to draw conclusions, generate explanations, and understand the connections across scientific concepts, often in unfamiliar situations and complex contexts. While there is some hierarchy in the complexity of thinking processes across the three cognitive domains (from knowing to applying to reasoning),[16] applying and reasoning items can ask students to access these higher-order thinking skills using simple or more complex science facts. Therefore, each cognitive domain contains tasks representing a full range of item difficulty. Each cognitive domain also consists of a subset of *cognitive areas*, each defined by a verb that reflects the overarching thinking process. The three cognitive domains and their associated cognitive areas are described in more detail later in this chapter.

The three cognitive domains are used at both grades in the TIMSS science assessment; however, the target percentages for each domain vary between fourth and eighth grade. Exhibit 2.2 shows the target percentages in terms of the number of item score points for each of the three cognitive domains at the fourth and eighth grades. Previous TIMSS cycles included a higher percentage of score points devoted to knowing items at the fourth grade compared to TIMSS 2027. The TIMSS 2027 Science Framework decreases the percentage of score points devoted to knowing items at the fourth grade to emphasize the reasoning cognitive domain, which aligns with the cognitive demands of engaging in the scientific inquiry process. The percentage of score points for items that ask students to engage in reasoning is even higher at the eighth grade compared to the fourth grade.

Exhibit 2.2: Target Percentages of the TIMSS 2027 Science Assessment Devoted to Cognitive Domains at the Fourth and Eighth Grades

Cognitive Domains	Percentages by Grade	
	Fourth Grade	Eighth Grade
Knowing	35%	35%
Applying	40%	35%
Reasoning	25%	30%

Science Practices and Ways of Thinking in TIMSS 2027

Scientific knowledge is developed through scientific inquiry: rigorous investigation of the natural world using key science practices and scientific ways of thinking to answer questions and solve problems. Scientific ways of thinking include engaging in scientific reasoning processes[17] that utilize scientific concepts across disciplines, such as recognizing patterns and reasoning using cause and effect,[18] to support these processes. Science students must become proficient in these practices and ways of thinking to develop knowledge and understanding of scientific concepts. Engaging in science practices and ways of thinking also enables students to understand how the scientific enterprise is conducted and, by extension, understand and appreciate the nature of science and scientific knowledge.[19,20] Increasing emphasis has been placed on scientific inquiry in many countries' current science curricula, standards, and frameworks.[21,22,23]

In the TIMSS 2027 science frameworks, the key science practices are embedded within the cognitive domains of reasoning and applying, and the practices are explicated with examples in the appropriate cognitive areas. The scientific ways of thinking are integrated into the cognitive domains implicitly, as they overlap with the defined cognitive processes. The practice of science and scientific thinking are strongly connected to the area of science under study and, therefore, cannot be assessed in isolation. Some items in the TIMSS 2027 science assessment at both the fourth and eighth grades will assess one or more of these important science practices together with content specified in the content domains. Students can engage in science practices and ways of thinking in the context of all the content domains.

The key science practices highlighted in the TIMSS science frameworks include skills that students use in a systematic way to conduct scientific investigations and that are applicable to all science disciplines. The following practices are distinguished in the TIMSS science assessment:

- **Practice 1**: Asking questions based on observations and theories and formulating hypotheses (embedded in the cognitive areas *Relate* and *Predict*).
- **Practice 2**: Designing investigations and generating evidence (embedded in the cognitive areas *Use Models* and *Design*).
- **Practice 3**: Working with data (embedded in the cognitive area *Interpret Information*).
- **Practice 4**: Answering research questions (embedded in the cognitive areas *Explain*, *Evaluate*, and *Draw Conclusions*).
- **Practice 5**: Making arguments from evidence (embedded in the cognitive areas *Justify* and *Generalize*).

While these practices are presented here as an ordered list, the complexity of scientific inquiry means that the process of employing them is, in reality, most often nonlinear and carried out iteratively.

While the cognitive domains and science practices are captured in all items in the TIMSS science assessments, problem-solving and inquiry tasks (PSIs) offer extended measurement of the science practices by including multiple steps of the inquiry process and higher-order cognitive skills across several items situated within more complex scenarios. PSIs comprise independent items individually assigned to one content and cognitive domain per item as defined in the remainder of this framework. However, PSIs establish a way to assess these domains more deeply and authentically, relying on a shared context across items to guide students through a wider range of cognitive processes and multiple steps of the inquiry process throughout the task.[24] This prepares students to engage with more complex scenarios and inquiry-based contexts than could be achieved in a single TIMSS item. Further information on characteristics of PSIs can be found in the TIMSS 2027 Guidelines for Developing PSIs.[25]

The next two sections of this chapter present the TIMSS 2027 science content domains for fourth and eighth grades, followed by a description of the cognitive domains which is applicable to both grades.

TIMSS 2027 Science Content Domains—Fourth Grade

Three major content domains define the science content for the TIMSS Science fourth-grade assessment: *biology*, *physical science*, and *earth science*.

Biology

The study of biology at the fourth grade provides students with an opportunity to capitalize on their innate curiosity and begin to understand the living world around them. In TIMSS 2027, biology is represented by six topic areas:

I. Characteristics and Life Processes of Organisms

II. Life Cycles, Reproduction, and Heredity

III. Diversity and Adaptation

IV. Ecosystems

V. Human Health

VI. Biological Investigations

By the fourth grade, students are expected to be building a base of knowledge about general characteristics of organisms, how they function, and how they interact with other organisms and with their environment. Students also should be familiar with basic science concepts related to life cycles, heredity, and human health that, in later grades, will lead to a more sophisticated understanding of how the human body functions. Students should know the basic features of biological investigations and the common materials or equipment they should use to make observations and collect data in biology contexts.

I. Characteristics and Life Processes of Organisms

1. Differences between living and nonliving things and what living things require to live:
   A. Recognize and describe differences between living and nonliving things (i.e., living things can reproduce, grow and develop, respond to stimuli, and die; and nonliving things cannot do all of these things).

   B. Identify what living things (i.e., plants and animals) require in order to live (i.e., air, food or light, water, and an environment in which to live).*

2. Physical and behavioral characteristics of major groups of living things:
   A. Compare and classify major groups of living things (i.e., animals and plants; mammals, birds, fish, reptiles, and insects) based on their physical and behavioral characteristics.

   B. Identify or provide examples of members of major groups of animals (i.e., mammals, birds, fish, reptiles, and insects).

3. Functions of major structures in living things:
   A. Relate major structures in animals to their functions (i.e., skin protects the body, bones support the body, lungs take in air, the heart circulates blood, the stomach digests food, and muscles move the body).
   B. Relate major structures in plants to their functions (i.e., roots absorb water and nutrients and anchor the plant; leaves make food; the stem keeps the plant upright and transports water, food, and nutrients; petals attract pollinators; flowers produce fruits and seeds; and seeds produce new plants).

4. Sustaining life and maintaining conditions under external changes:
   A. Recognize that plants produce their own food, using (sun)light, air, and water;* explain that animals eat plants or other animals to get the food they need.*
   B. Recognize and describe how animals respond to changes in external conditions (e.g., temperature and danger);* recognize and describe how the human body responds to changes in external conditions (e.g., temperature), and how it reacts to physical activity (e.g., exercise).

II. Life Cycles, Reproduction, and Heredity

1. Stages of life cycles and differences among the life cycles of common plants and animals:
   A. Identify stages of the life cycles of plants (i.e., germination, growth and development, pollination, flower and fruit production, and seed dispersal).
   B. Recognize, compare, and contrast the life cycles of common animals (e.g., humans, frogs, butterflies).

2. Inheritance and reproduction strategies:
   A. Recognize that plants and animals reproduce with individuals of their own kind but of the opposite sex to produce offspring with features that closely resemble those of the parents; distinguish between features of plants and animals that are inherited from their parents (e.g., number of petals, color of petals, eye color, hair color), and those that are not (e.g., some broken branches in a tree, length of human hair).
   B. Identify and describe different strategies of plants and animals that increase the number of offspring that survive (e.g., a plant producing many seeds, mammals caring for their young).

III. Diversity and Adaptation

1. Physical features and behaviors of living things that help them survive in their environment:
   A. Associate physical features of plants and animals with the environments in which they live and describe that they survive because of these features (e.g., a thick stem, a waxy coating, and a deep root help a plant survive in an environment with little water; the coloring of an animal helps camouflage it from predators).*
   B. Associate behaviors of animals with the environments in which they live and describe how these behaviors help them to survive (e.g., migration or hibernation helps an animal to stay alive when food is scarce).*

IV. Ecosystems

1. Common ecosystems:
   A. Relate common plants and animals (e.g., evergreen trees, frogs, lions) to common ecosystems (i.e., temperate forest, rainforest, desert, savannah, arctic, pond, river, and ocean).*
2. Relationships in ecosystems:
   A. Complete a linear model of a food chain using common plants and animals from common ecosystems (i.e., temperate forest, rainforest, desert, savannah, arctic, pond, river, and ocean) and describe the role of the organisms at each link in the food chain.*
   B. Identify predators and their prey.
   C. Recognize and explain that some living things in an ecosystem compete with others for resources (i.e., food, water, light, and space).*
3. The impact of humans on ecosystems:
   A. Provide examples of the effects of pollution on humans, plants, and animals (e.g., polluted air can cause lung diseases, animals might die from drinking polluted water).*
   B. Recognize that human behavior has negative and positive effects on populations in an ecosystem (e.g., shrinking habitats of polar bears due to global warming, polluting rivers by releasing waste, protection of elephant populations in national parks).*

V. Human Health

1. Transmission and prevention of diseases:
   A. Relate the transmission of common communicable diseases to human contact (e.g., touching, sneezing, coughing); identify or describe some methods of preventing disease transmission (e.g., vaccination, washing hands, keeping a physical distance from people who are sick, wearing a mask).

1. Ways of maintaining good health:
   A. Describe everyday behaviors that promote good physical and mental health (e.g., a balanced diet, exercising regularly, brushing teeth, getting enough sleep, taking time for relaxation, wearing sunscreen); identify common food sources included in a balanced diet (i.e., fruits and vegetables; grains and cereals; milk products; fish, meat, eggs, nuts, and beans).

VI. Biological Investigations

1. Features of and equipment used in biological investigations:
   A. Recognize basic features of a biological investigation (e.g., the fair setup of an experiment that investigates how light affects plant growth; the difference between observations of insects and inferences about their behavior); recognize how common materials or equipment (e.g., magnifying glass, tweezers) can be used during biological investigation.

Physical Science

At the fourth grade, students learn how many physical phenomena that they observe in their everyday lives can be explained through an understanding of physical science concepts. The topic areas for the physical science content domain at the fourth grade are:

I. Properties of Matter and Changes in Matter

II. Energy and Energy Transfer

III. Light and Sound

IV. Electricity and Magnetism

V. Motion and Forces

VI. Physical Science Investigations

Fourth-grade students should have an understanding of physical states of matter (solid, liquid, and gas), as well as common changes in the state of matter; this forms a foundation for the study of both chemistry and physics in the middle and upper grades. At this level, students should also know common forms and sources of energy and their practical uses, and understand basic concepts about light, sound, electricity, and magnetism. The study of forces and motion emphasizes an understanding of forces as they relate to movements students can observe, such as the effect of gravity or pushing and pulling. Students should know the basic features of investigations in physical science and the common materials or equipment they should use for measurement and collecting data during physical science investigations.

I. Properties of Matter and Changes in Matter

1. States of matter:
   A. Identify the three states of matter (i.e., solid, liquid, and gas) and describe their defining characteristics in terms of shape and volume; identify the state of water at a given temperature (i.e., ice, water, and water vapor).
   B. Recognize that matter can be changed from one state to another by heating or cooling; describe changes in the state of water (i.e., melting, freezing, evaporation, and condensation).
2. Physical properties as a basis for classifying matter:
   A. Compare and sort objects and materials on the basis of physical properties (i.e., weight/mass, volume, state of matter, ability to conduct heat or electricity, ability to float or sink in water, and ability to be attracted by a magnet). [Note: Students in the fourth grade are not expected to differentiate between mass and weight.]
   B. Identify properties of metals (i.e., conducting electricity and conducting heat) and relate these properties to uses of metals (e.g., a copper electrical wire, an iron cooking pot).

3. Physical and chemical changes observed in everyday life:
   A. Identify observable changes in materials that do not result in new materials with different properties (e.g., dissolving sugar in tea, crushing an aluminum can, freezing of water into ice); identify observable changes in materials that do result in new materials with different properties (e.g., decaying—such as food spoiling; burning; rusting).
   B. Describe examples of mixtures and how they can be physically separated (i.e., sifting, floating/sinking, filtration, evaporation, and magnetic attraction).
   C. Identify ways of increasing how quickly a solid material dissolves in a given amount of water (i.e., increasing the temperature, stirring, and breaking the solid into smaller pieces); distinguish between weak and strong concentrations of simple solutions (e.g., water sweetened with one versus two lumps of sugar).

II. Energy and Energy Transfer

1. Uses of energy in everyday life:
   A. Recognize that humans need energy for different purposes (e.g., heating, powering devices), and that this energy is provided in different forms (e.g., heat, electricity).
2. Heating and cooling:
   A. Describe that when a hot object is brought into contact with a cold object or surroundings, the temperature of the hot object decreases while the temperature of the cold object or surroundings increases.

III. Light and Sound

1. Light in everyday life:
   A. Relate common physical phenomena (i.e., shadows, reflections, and rainbows) to the behavior of light.
2. Sound in everyday life:
   A. Relate common physical phenomena (i.e., vibrating objects and echoes) to the production and behavior of sound.

IV. Electricity and Magnetism

1. Electricity and simple electrical devices:
   A. Recognize that electrical energy can be transformed into other forms of energy (e.g., heat, light, sound).
   B. Explain in the context of simple electrical devices (e.g., a flashlight) that electrical systems require a complete/unbroken electrical pathway; identify diagrams representing complete simple circuits.
2. Magnetic attraction and repulsion:
   A. Recognize that magnets have two poles, and that like poles repel and opposite poles attract.
   B. Recognize that magnets can be used to attract most metal objects.

V. Motion and Forces

1. Common forces and the motion of objects:
   A. Identify gravity as the force that draws objects to Earth.
   B. Recognize that pushing and pulling forces may cause an object to change its motion; compare the effects of these forces (i.e., pushes and pulls) of different strengths acting on an object in the same or opposite directions; and recognize that resistive forces (i.e., friction and air resistance) work against the direction of motion.
2. Simple machines:
   A. Recognize that simple machines (e.g., levers, pulleys, gears, ramps) help make motion easier (i.e., reduce the amount of force required or change the direction of the force).

VI. Physical Science Investigations

1. Features of and use of equipment in physical science investigations:
   A. Recognize basic features of an investigation in physical science (e.g., testable scientific questions related to dissolving sugar in water; the need for multiple measurements when comparing methods to avoid cooling of water in a mug).
   B. Recognize how common equipment (e.g., scale, stopwatch) can be used during an investigation in physical science.

Earth Science

Earth science is the study of Earth and its place in the Solar System, and at fourth grade focuses on the study of phenomena and processes that students can observe in their everyday lives. While there is no single picture of what constitutes an earth science curriculum that applies to all countries, the five topic areas included in this domain are generally considered to be important for students at the fourth grade to understand as they learn about the planet on which they live and its place in the Solar System:

I. Earth's Physical Features, Processes, and History

II. Earth's Atmosphere

III. Earth's Resources, their Use and Conservation

IV. Earth in the Solar System

V. Earth Science Investigations

At this level, students should have some general knowledge about the structure and physical characteristics of Earth's surface, and about the use of Earth's most important resources. Students also should be able to describe some of Earth's processes in terms of observable changes and understand the time frame over which such changes have occurred. Fourth-grade students should also demonstrate some understanding of Earth's place in the Solar System based on observations of patterns of change on Earth and in the sky. Students should know the equipment they can use during earth science investigations to collect data and make observations.

I. Earth's Physical Features, Processes, and History

1. Physical characteristics of the Earth's surface:
   A. Recognize that Earth's surface is made up of land and water in unequal proportions (more water than land) and is surrounded by air; describe where fresh and salt water are found.*
2. Earth's history:
   A. Recognize that wind and water change Earth's landscape (e.g., sand dunes, mountains, river valleys) and that some features of Earth's landscape (e.g., mountains, river valleys) result from changes that happen very slowly over a long time.
   B. Recognize that some remains (fossils) of animals and plants that lived on Earth a long time ago are found in rocks and ice and make simple deductions about changes in Earth's surface from the location of these remains.

II. Earth's Atmosphere

1. Weather and climates on Earth:
   A. Describe how weather (i.e., temperature, humidity, and precipitation in the form of rain or snow, clouds, and wind, all at a specific time) can vary from day to day and with geographic location.*
   B. Describe how average temperature and precipitation can change with the seasons and location; recognize that the average temperature on Earth has increased over the last century and identify some effects of this increase on Earth's physical characteristics (e.g., ocean levels have increased, ice caps have melted, rivers have dried up, deserts have grown bigger).*

III. Earth's Resources, their Use, and Conservation

1. Earth's resources:
   A. Recognize how some of Earth's resources (i.e., water, wind, soil, forests, minerals, and fossil fuels—coal, oil, natural gas) are used in everyday life (e.g., as an energy source, for building houses); recognize that some of these resources are nonrenewable (e.g., mined minerals, fossil fuels).*
   B. Explain the importance of using Earth's resources (i.e., water, wind, soil, forests, minerals, and fossil fuels—coal, oil, natural gas) responsibly.*

IV. Earth in the Solar System

1. Objects in the Solar System and their movements:
   A. Describe the Solar System as the Sun and the planets that revolve around it; recognize that the Earth has a moon that revolves around it, and that from Earth the Moon looks different at different times of the month.
2. Earth's motion and related patterns observed on Earth:
   A. Explain how day and night are related to Earth's daily rotation about its axis.
   B. Recognize that Earth revolves around the Sun in one year.

V. Earth Science Investigations

1. Use of equipment in earth science investigations:
   A. Recognize how common equipment (e.g., thermometer, compass, rain gauge) can be used during earth science investigations.

TIMSS 2027 Science Content Domains—Eighth Grade

Four major content domains define the science content for the TIMSS Science eighth-grade assessment: *biology*, *chemistry*, *physics*, and *earth science*.

Biology

At the eighth grade, students build on the foundational biological knowledge they learned in the primary grades and develop an understanding of many of the most important concepts in biology. The biology domain includes seven topic areas:

I. Characteristics and Life Processes of Organisms

II. Cells and their Functions

III. Life Cycles, Reproduction, and Heredity

IV. Diversity, Adaptation, and Natural Selection

V. Ecosystems

VI. Human Health

VII. Biological Investigations

Concepts learned in each of these topic areas are essential for preparing students for more advanced study. Therefore, eighth-grade students should have a foundational understanding of the relationship between structure and function across different levels of biological organization, and of energy flow in biological processes. Moreover, basic knowledge of the role of DNA in reproduction and heredity provides a foundation for more advanced study of molecular biology and molecular genetics. Learning the concepts of adaptation and natural selection provides a foundation for understanding evolution, and an understanding of processes and interactions in ecosystems is essential for students to begin to think about how to develop solutions to many environmental challenges. Developing a science-based understanding of the role of the immune system in human health enables students to improve the condition of their own and others' lives and is foundational to health-related and medical studies. Finally, students are expected to know and be able to explain the primary features of a sound investigation in biology, including how materials and equipment should be used to collect data and make observations in biological investigations.

I. Characteristics and Life Processes of Organisms

1. Differences among major taxonomic groups of organisms:
   A. Identify the defining characteristics that differentiate among major taxonomic groups (e.g., life cycles, respiratory systems, reproduction) of organisms (i.e., bacteria, fungi, plants, and animals; mammals, birds, fish, reptiles, amphibians, and insects).
   B. Recognize and categorize organisms that are examples of major taxonomic groups of organisms (i.e., bacteria, fungi, plants, and animals; mammals, birds, fish, reptiles, amphibians, and insects).

2. Structures and functions of major organ systems:
   A. Locate and identify major organ systems (i.e., respiratory, digestive, skeletal, and nervous systems), and their constituent organs (e.g., lungs, stomach, brain) in the human body.
   B. Compare and contrast major organs and major organ systems in humans and other vertebrates (e.g., lungs in humans compared with gills in fish).
   C. Explain the role of major organs and major organ systems in sustaining life (e.g., organs involved in circulation and respiration).

3. Physiological processes in plants and animals:
   A. Explain how animals respond to external and internal changes to maintain stable body conditions (e.g., increased heart rate during exercise, feeling thirsty when dehydrated, shivering in cold).
   B. Describe the function (i.e., to make sugar using energy) and basic process of photosynthesis (i.e., captures energy from light and requires carbon dioxide, water, and chlorophyll; produces glucose/sugar; and releases oxygen).*
   C. Describe the function (i.e., to release energy from sugar) and basic process of cellular respiration (i.e., requires oxygen and glucose/sugar; produces energy; and releases carbon dioxide and water).*

II. Cells and Their Functions

1. The structures and functions of cells:
   A. Explain that living things are made of cells and that these carry out life functions and reproduce by division.
   B. Identify major cell structures (i.e., cell wall, cell membrane, nucleus, cytoplasm, chloroplast, vacuole, and mitochondria) and describe the primary functions of these structures.
   C. Recognize that cell walls, chloroplasts, and vacuoles differentiate plant cells from animal cells.
   D. Explain that tissues, organs, and organ systems are formed from groups of cells with specialized structures and functions.

III. Life Cycles, Reproduction, and Heredity

1. Sexual reproduction and inheritance in plants and animals:
   A. Recognize that sexual reproduction involves the fertilization of an egg cell by a sperm cell to produce offspring that are similar but not identical to either parent; relate the inheritance of traits to organisms passing on genetic material to their offspring.
   B. Recognize that an organism's traits are encoded in its DNA; recognize that DNA is genetic information found in chromosomes located in the nucleus of each cell.
   C. Distinguish inherited characteristics from acquired or learned characteristics.

IV. Diversity, Adaptation, and Natural Selection

1. Variation as the basis for natural selection:
   A. Recognize that variations in physical and behavioral characteristics among individuals in a population give some individuals an advantage within the ecosystem to survive and pass on their characteristics to their offspring; recognize that in a changing environment the survival or extinction of a species is related to this reproductive success.
2. Evidence for changes in life on Earth over time:
   A. Draw conclusions about the relative lengths of time different organisms and groups of organisms have existed on Earth using fossil evidence.
   B. Describe how similarities and differences among living species and fossils provide evidence of the changes that occur in living things over time, and recognize that the degree of similarity of characteristics provides evidence of common ancestry.

V. Ecosystems

1. Natural, urban, and rural ecosystems:
   A. Contrast and compare natural, rural, and urban ecosystems with regard to the features of and the organisms within.*
2. The flow of energy in ecosystems:
   A. Describe the flow of energy in an ecosystem (i.e., energy flows from producers to consumers to decomposers, and only a small part of the energy is passed from one level to the next); construct and interpret energy pyramids.*
3. The cycling of water, oxygen, and carbon in ecosystems:
   A. Describe the role of living things in cycling water through an ecosystem (i.e., plants take in water from the soil and give off water through their leaves during transpiration; and animals take in water by drinking and release water during respiration and as waste).*
   B. Describe the role of living things in cycling oxygen and carbon through an ecosystem (i.e., plants take in carbon dioxide from the air and release oxygen into the air; and animals take in oxygen from the air and release carbon dioxide into the air).*

4. Relationships in ecosystems:
    A. Identify and provide examples of producers, consumers, and decomposers; construct and interpret food web diagrams.*
    B. Describe and provide examples of competition among populations or organisms in an ecosystem.*
    C. Describe and provide examples of predation in an ecosystem.*
    D. Describe and provide examples of mutualism and parasitism among populations of organisms in an ecosystem (e.g., birds or insects pollinating flowers, ticks living on deer or cattle).*

5. Factors affecting population size in an ecosystem:
    A. Identify factors that limit the size of a population (e.g., predators, food resources, water supply).*
    B. Predict how changes in an ecosystem (e.g., changes in the water supply, the introduction of a new population, migration) can affect the balance among populations.*

6. Human impact on ecosystems:
    A. Describe and provide examples of the effects of air, water, and soil pollution on humans, plants, and animals (e.g., water pollution can reduce plant and animal life in the water system).*
    B. Describe and explain how human behavior can have positive effects (e.g., replanting forests, reducing air and water pollution, protecting endangered species) or negative (e.g., allowing factories to release wastewater into water systems and pollutants into the air) effects on ecosystems.*

VI. Human Health

1. Causes, transmission, prevention of, and resistance to diseases:
    A. Describe causes, transmission, and prevention of common viral, bacterial, and parasite diseases (e.g., influenza, measles, HIV, COVID-19, tetanus, malaria).
    B. Describe the role of the body's immune system in resisting disease and promoting healing (e.g., antibodies in the blood help the body resist infection; and white blood cells fight infection).
    C. Recognize that vaccines can train the immune system to prevent both viral and bacterial diseases, while antibiotics can help the immune system to overcome bacterial infections; recognize that antibiotics may become less effective when bacteria change.

2. Ways of maintaining good health:
   A. Explain the importance of diet, exercise, and other lifestyle choices in maintaining mental and physical health and preventing illness (e.g., heart disease, high blood pressure, diabetes, skin cancer, lung cancer).
   B. Identify the dietary sources and roles of nutrients (i.e., vitamins, minerals, proteins, carbohydrates, and fats) in a healthy diet.

VII. Biological Investigations

1. Features of and equipment used in biological investigations:
   A. Identify and explain characteristics of a sound biological investigation (e.g., a researchable inquiry question about changes in an ecosystem, the difference between control and treatment variables in a biological investigation); identify how materials or equipment (e.g., a microscope) can be used during biological investigations.

Chemistry

At the eighth grade, students' study of chemistry extends beyond developing an understanding of everyday phenomena to learning the central concepts and principles that are needed for understanding practical applications of chemistry and undertaking later, more advanced study. The chemistry domain includes four topic areas:

I. Composition of Matter

II. Properties of Matter

III. Chemical Reactions

IV. Chemistry Investigations

The composition of matter topic area focuses on differentiating elements, compounds, and mixtures and understanding the particulate structure of matter. Included in this area also is the use of the periodic table as an organizing principle for the elements. At a more macroscopic level, the properties of matter topic area focuses on distinguishing between physical and chemical properties of matter and understanding the properties of mixtures, solutions, acids, and bases. The study of chemical reactions focuses on the characteristics of chemical changes, the conservation of matter during chemical changes, and the role of chemical bonds. Finally, the topic area on chemistry investigations includes the understanding of the primary features of a sound chemistry investigation and knowledge of the laboratory equipment used to make measurements during chemistry investigations.

I. Composition of Matter

1. Structure of atoms and molecules:
   A. Describe atoms as composed of subatomic particles (i.e., negatively charged electrons surrounding a nucleus containing positively charged protons and neutrons with no charge).
   B. Describe the structure of matter in terms of particles (i.e., atoms and molecules) and describe molecules as combinations of atoms (e.g., H_2O, O_2, CO_2).
   C. Recognize that a chemical bond results from the attraction between atoms in a compound and that the atoms' electrons are involved in this bonding.
2. Elements, compounds, and mixtures:
   A. Describe the differences among elements, compounds, and mixtures; differentiate between pure substances (i.e., elements and compounds) and mixtures (homogeneous and heterogeneous) on the basis of their formation and composition.
3. The periodic table of elements:
   A. Recognize that the periodic table is an arrangement of the elements; recognize and describe that the elements are arranged in order of the number of protons in the nuclei of the atoms of each element.
   B. Recognize that an element's properties (e.g., metal or nonmetal, reactivity) can be predicted from its location in the periodic table (i.e., row or period, and column or group/family) and that elements in the same group have some properties in common.

II. Properties of Matter

1. Physical and chemical properties as a basis for classifying matter and using materials:
   A. Distinguish between physical and chemical properties of matter.
   B. Classify common substances and materials according to physical properties (e.g., density, melting or boiling point, solubility, magnetic properties, electrical or thermal conductivity).
   C. Classify common substances and materials according to their chemical properties (e.g., reactivity, flammability) and relate uses of materials to their chemical properties.
2. Mixtures and solutions:
   A. Explain how physical methods can be used to separate mixtures into their components.
   B. Describe solutions in terms of substance(s) (i.e., solid, liquid, or gas solutes) dissolved in a solvent and relate the concentration of a solution to the amounts of solute and solvent present.
   C. Explain how temperature, stirring, and surface area in contact with the solvent affect the rate at which solutes dissolve.

3. Properties of acids and bases:
   A. Recognize everyday substances as acids or bases based on their properties (e.g., acidic foods usually have a sour taste, bases usually do not react with metals, bases feel slippery).
   B. Recognize that acids have a pH of less than 7, while bases have a pH of more than 7; recognize that acids and bases can neutralize each other; and recognize that both acids and bases react with indicators to produce different color changes.

III. Chemical Reactions

1. Characteristics of chemical reactions:
   A. Recognize that in a chemical reaction one or more pure substances/reactants transform into different pure substances/products, in contrast to a physical change; and describe evidence (i.e., temperature changes, gas production, precipitate formation, color change, or light emission) of a chemical reaction.
2. Matter and energy in chemical reactions:
   A. Recognize that matter is conserved during a chemical reaction and that all of the atoms present at the beginning of the reaction are present at the end of the reaction, but that they are rearranged to form new substances.
   B. Recognize chemical reactions that release energy/heat (e.g., burning) versus other reactions that require energy (e.g., the reaction of substances in a chemical cold pack).
   C. Recognize that chemical reactions occur at different rates and that the rate of reaction can be affected by changing the conditions under which the reaction is taking place (i.e., surface area, temperature, and concentration).

IV. Chemistry Investigations

1. Features of and equipment used in chemistry investigations:
   A. Identify and explain characteristics of a sound chemistry investigation (e.g., testable inquiry questions related to the rate of chemical reactions, the importance of changing only temperature between measurements of reaction rates).
   B. Recognize how materials and common lab equipment (e.g., balance, beaker, test tube) can be used appropriately in a chemistry investigation (e.g., how to work safely with chemical substances).

Physics

As in the chemistry domain, students' study of physics at the eighth grade extends beyond understanding the scientific basis of common everyday observations to learning many of the central physics concepts that are needed for understanding practical applications of physics or for undertaking advanced study later in their education. The physics domain includes six topic areas:

I. Physical States and Changes in Matter

II. Energy Transformation and Transfer

III. Light and Sound

IV. Electricity and Magnetism

V. Motion and Forces

VI. Physics Investigations

Eighth-grade students are expected to be able to describe processes involved in changes in the state of matter and relate states of matter to the distance and movement among particles. They should also be able to identify different forms of energy, describe simple energy transformations, apply the principle of conservation of total energy in practical situations, and understand the difference between thermal energy (heat) and temperature. Students at this level also are expected to know some basic properties of light and sound, relate these properties to observable phenomena, and solve practical problems involving the behavior of light and sound. In the topic area of electricity and magnetism, students should be familiar with the electrical conductivity of common materials, current flow in electric circuits, and the difference between simple series and parallel circuits. They also should be able to describe the properties and uses of permanent magnets and electromagnets. Students' understanding of motion and forces should include knowing the general types and characteristics of forces and how simple machines function. They should understand the concepts of pressure and density and be able to predict qualitative changes in motion based on the forces acting on an object. Students are expected to know and be able to explain the primary features of a sound investigation in physics, including how common equipment can be used to make measurements during physics investigations.

I. Physical States and Changes in Matter

1. Motion of particles in solids, liquids, and gases:
   - A. Recognize that atoms and molecules in matter are in constant motion and recognize the differences in relative motion and distance between particles in solids, liquids, and gases; apply knowledge about the movement of and distance between atoms and molecules to explain the physical properties of solids, liquids, and gases (i.e., volume, shape, density, and compressibility).
   - B. Relate changes in temperature to changes in the movement of and distance between particles for all states of matter; relate changes in temperature to changes in the volume and/or pressure of gases and to the expansion of liquids and solids.

2. Changes in states of matter:
   A. Describe changes of state (i.e., melting, freezing, evaporation, condensation, and sublimation) as resulting from an increase or decrease of thermal energy and recognize that temperature remains constant during melting, freezing, and boiling; explain that mass remains constant during changes of state.
   B. Relate the rate of change of state to physical factors (e.g., surface area, the temperature of the surroundings).

II. Energy Transformation and Transfer

1. Forms of energy and the conservation of energy:
   A. Identify different forms of energy (i.e., kinetic, potential, light, sound, electrical, thermal, and chemical).
   B. Describe the energy transformations that take place in common processes (e.g., combustion in an engine to move a car, photosynthesis, the production of hydroelectric power); recognize that the total energy of a closed system is conserved.
2. Thermal energy transfer:
   A. Relate the transfer of thermal energy from an object or an area at a higher temperature to one at a lower temperature to cooling and heating; recognize that hot objects cool off and cold objects warm up until they reach the same temperature as their surroundings.
   B. Relate the rate of transfer of thermal energy through a material to its thermal conductivity.

III. Light and Sound

1. Properties of light:
   A. Describe or identify basic properties of light (i.e., speed; transmission through different media; reflection, refraction, absorption; and splitting of white light into its component colors); relate the apparent color of objects to reflected or absorbed light.
   B. Solve practical problems involving the reflection of light from plane mirrors and the formation of shadows; interpret simple ray diagrams to identify the path of light.
2. Properties of sound:
   A. Describe or identify some basic properties of sound (i.e., sound is a wave phenomenon caused by vibrations; is characterized by loudness/amplitude and pitch/frequency; requires a medium for transmission; is reflected and absorbed by surfaces; and has a relative speed through different media, which is always slower than light) and relate this to common phenomena (e.g., echoes, hearing thunder after seeing lightning).

IV. Electricity and Magnetism

1. Conductors and the flow of electricity in electrical circuits:
   A. Identify materials as electrical conductors or insulators; identify electrical components or materials that can be used to complete circuits.
   B. Recognize complete and incomplete electrical pathways in simple, series, and parallel circuits and the difference between series and parallel circuits; interpret diagrams representing simple, series, and parallel circuits.

2. Properties and uses of permanent magnets and electromagnets:
   A. Relate properties of permanent magnets (i.e., two opposite poles, attraction/repulsion, and strength of the magnetic force varies with distance) to uses in everyday life (e.g., a directional compass).
   B. Describe the properties that are unique to electromagnets (i.e., the strength varies with current, number of coils, and type of metal in the core; the magnetic attraction can be turned on and off; and the poles can switch) and relate properties of electromagnets to uses in everyday life (e.g., doorbell, recycling factory).

V. Motion and Forces

1. Motion:
   A. Recognize the speed of an object as change in position/distance over time and acceleration as change in speed over time.
2. Common forces and their characteristics:
   A. Describe common mechanical forces (e.g., normal, friction, elastic, buoyant); recognize and describe weight as a force due to gravity.
   B. Recognize that forces have strength and direction; recognize that for every action force there is an equal and opposite reaction force.
3. Effects of forces:
   A. Describe the functioning of simple machines (e.g., levers, inclined planes, pulleys, gears).
   B. Explain floating and sinking in terms of density differences and the effect of buoyant force.
   C. Describe pressure in terms of force and area; describe effects related to pressure (e.g., water pressure increasing with depth, a balloon expanding when inflated).
   D. Predict qualitative changes in motion (speed and direction) of an object based on the forces acting on it; recognize and describe how resistive forces (i.e., friction and air resistance) affect motion (e.g., the contact area between surfaces can increase friction and impede motion).

VI. Physics Investigations

1. Features of and equipment used in physics investigations:
   A. Identify and explain characteristics of a sound physics investigation (e.g., asking answerable scientific questions about weather conditions, repeating measurements of temperature for accuracy).
   B. Recognize how common equipment (e.g., scale, ampere meter, spring balance) can be used appropriately in a physics investigation (e.g., working safely with glassware).

Earth Science

Topics covered in the teaching and learning of earth science draw on the fields of geology, astronomy, meteorology, hydrology, and oceanography, and are related to concepts in biology, chemistry, and physics. Although separate courses in earth science covering all these topics are not taught in all countries, it is expected that understandings related to earth science topic areas will have been included in a science curriculum covering the physical and life sciences or in separate courses such as geography and geology. The TIMSS 2027 Science Framework identifies the following topic areas that are universally considered to be important for students at the eighth grade to understand as they learn about the planet on which they live and its place in the universe:

I. Earth's Physical Features, Processes, and History

II. Earth's Atmosphere

III. Earth's Resources, Their Use, and Conservation

IV. Earth in the Solar System

V. Earth Science Investigations

Eighth-grade students are expected to have some general knowledge about the structure and physical features of Earth, including Earth's structural layers, and the atmosphere. Students also should have a conceptual understanding of processes, cycles, and patterns, including geological processes that have occurred over Earth's history, the water cycle, and patterns of weather and climate. Students should demonstrate knowledge of Earth's resources and their use and conservation and relate this knowledge to practical solutions to resource management issues. At this level, the study of Earth and the Solar System includes understanding how observable phenomena relate to the movements of Earth and the Moon, and describing the features of Earth, the Moon, and other planets. Students should also know what equipment is appropriate to use and how to use it to collect data during earth science investigations.

I. Earth's Physical Features, Processes, and History

1. Earth's structure:
   A. Describe the structure of the Earth (i.e., crust, mantle, inner core, and outer core) and the physical characteristics of these distinct parts.
   B. Describe the distribution of water on Earth in terms of its physical state (i.e., ice, water, and water vapor), and fresh versus salt water*; describe methods for ensuring that fresh water is available for human activities (i.e., desalination and purification).*

2. Geological processes:
   A. Describe the general processes involved in the rock cycle (i.e., the cooling of lava; weathering and erosion of rock to sediment; heat and pressure transforming sediment into rock; and melting of rock into magma).
   B. Identify or describe large scale changes to Earth's surface (e.g., mountain building), resulting from major geological events (i.e., glaciation; the movement of tectonic plates and subsequent earthquakes and volcanic eruptions; and the impact of an asteroid).
   C. Explain the formation of fossils and fossil fuels;* use evidence from the fossil record to explain how the environment has changed over long periods of time.

II. Earth's Atmosphere

1. Components of Earth's atmosphere and atmospheric conditions:
   A. Recognize that Earth's atmosphere is a mixture of gases; identify the relative abundance of its main components (i.e., nitrogen, oxygen, water vapor, and carbon dioxide).*

   B. Relate changes in atmospheric conditions (i.e., temperature and pressure) to changes in altitude.

2. Earth's water cycle:
   A. Describe the processes in Earth's water cycle (i.e., evaporation, condensation into clouds, cloud movement, precipitation, and water flow);* recognize the role of the water cycle in the renewal of fresh water on Earth's surface;* and recognize the Sun as the source of energy for the water cycle.

   B. Recognize that cloud formation and precipitation result from the condensation of water vapor due to the cooling of air, and that air cools when it rises (due to, e.g., warm surface, mountain ridges, colliding air masses).

3. Weather and climate:
   A. Distinguish between weather (i.e., day-to-day variations in temperature, humidity, different types of precipitation, clouds, and wind) and climate (i.e., long-term typical weather patterns in a geographic area).*

   B. Interpret climate data (i.e., graphs, tables, or maps) to identify climate types (e.g., tropical, arid, temperate, continental, polar); relate the climate and seasonal variations in average weather patterns to global and local factors (i.e., hemisphere, latitude, altitude, and geography).

4. Climate change:
   A. Identify or describe possible causes of global climate change (e.g., release of greenhouse gases by burning fossil fuel, volcanic eruptions).*

   B. Interpret data (i.e. graphs, tables, or maps) to identify evidence of local and global climate change (e.g., time series of global temperature, maps of decreasing ice caps).*

III. Earth's Resources, Their Use, and Conservation

1. Energy resources:
   A. Identify different energy sources that are used by humans and discuss their advantages and disadvantages (i.e., sunlight, wind, moving water, geothermal, wood and other biomass, nuclear, and fossil fuels: oil, coal, natural gas).*

2. Managing Earth's resources:
   A. Provide examples of Earth's renewable (e.g., forest, wind energy) and nonrenewable resources (e.g., mined minerals, fossil fuels).*

   B. Explain how common methods of land use (e.g., farming, logging, mining) can affect Earth's resources.*

   C. Explain the importance of the conservation of Earth's resources (e.g., water, soil, minerals), and describe and compare methods of conservation, including methods of waste management (i.e., reduce, reuse, and recycle).*

IV. Earth in the Solar System

1. Observable phenomena on Earth resulting from movements of Earth and the Moon:
   A. Describe the effects of the Earth's daily rotation around its axis (i.e., day and night and changing shadows) and describe how its annual revolution around the Sun, given the tilt of its axis, results in different seasons.
   B. Recognize that tides are caused by the gravitational pull of the Moon, and relate phases of the Moon and eclipses to the relative positions of Earth, the Moon, and the Sun.
2. The Sun, Earth, Moon, and planets:
   A. Recognize that the Sun is a star and provides light and heat to each member of the Solar System; explain that the Sun produces its own light, but that planets and moons are visible because of light reflected from the Sun.
   B. Interpret data (i.e., graphs, tables, or maps) to identify differences between features of Earth, the Moon, and other planets (e.g., presence and composition of an atmosphere, gravity, period of revolution and rotation); recognize that the force of gravity keeps planets and moons in their orbits.

V. Earth Science Investigations

1. Equipment used in earth science investigations:
   A. Recognize how common equipment (e.g., telescope, compass) can be used during earth science investigations.

Defining Environmental Knowledge in TIMSS 2027

TIMSS has historically included topics related to environmental knowledge in its fourth- and eighth-grade science assessments. The first international comparison of students' environmental knowledge was published in the *TIMSS 2019 Environmental Awareness Results*.[26] In 2023, environmental knowledge was complemented with environmental attitudes, as measured by the context questionnaires (see Chapter 3: TIMSS 2027 Contextual Framework and the supplement TIMSS 2023 Environmental Attitudes and Behaviors Framework).[27] Both environmental knowledge and attitudes are needed to develop environmental awareness, the first step to becoming environmentally literate. Therefore, knowledge and attitudes together shape the concept of environmental awareness.[28,29]

Building on the efforts and results of the environmental knowledge subscale from TIMSS 2019 and TIMSS 2023, TIMSS 2027 incorporates a more comprehensive and expanded definition of environmental knowledge in the science framework, providing a foundation for the environmental knowledge subscale for this and future cycles: Environmental knowledge is the understanding of how natural systems work, including the relationships between living organisms, their physical surroundings, and the impact of human activities on the environment. It is a comprehensive term that includes not only knowing scientific facts, but also mastering different types of environmental knowledge, such as systems knowledge, action-related knowledge, and effectiveness knowledge.[30,31] Thus, environmental knowledge includes both knowing scientific concepts and understanding how humans interact with the natural world, major environmental issues, and potential solutions.[32]

Content Objectives Contributing to Environmental Knowledge

The nature of environmental knowledge is particularly interdisciplinary:[33] many environmental concepts incorporate knowledge from multiple content domains. In TIMSS, environmental knowledge integrates concepts from the existing TIMSS content domains biology and earth science but is reported as an additional distinct subscale. More specifically, the knowledge that fourth- and eighth-grade students should have about the environment and environmental issues overlaps with some of the knowledge within the content domains of biology and earth science. Therefore, several content objectives in the TIMSS 2027 science frameworks are classified as measuring both the science content domain in which they are included, as well as environmental knowledge (i.e., specific items from biology and earth science are also assigned to the environmental knowledge subscale). For example, the objective about the impact of humans on the environment that is found within the biology content domain of the fourth-grade TIMSS 2027 science framework, "*Recognize that human behavior has negative and positive effects on populations in ecosystems (e.g., shrinking habitats of polar bears due to global warming, protection of elephant populations in national parks),*" is additionally classified to be used for the environmental knowledge subscale.

In general, the environmental knowledge subscale consists of the content objectives from biology and earth science that relate to climate change, Earth's resources, and ecosystem relationships. It also includes those biology and earth science objectives that directly improve understanding of these environmental concepts. For example, objectives on foundational topics, such as what living things need to survive and the formation of fossil fuels, are also included in the environmental knowledge subscale. In contrast, topics like cellular biology and Earth's structure are excluded as they do not relate directly nor are they foundational to interactions between natural systems and human activities. The content objectives from the TIMSS 2027 science frameworks for the fourth and eighth grades that have been selected to contribute to the environmental knowledge subscale have been marked with an asterisk.

For more information on environmental knowledge, see *Environmental Awareness in TIMSS 2023—Patterns in Achievement, Attitudes, Behaviors, and Contexts.*[34]

TIMSS 2027 Science Cognitive Domains—Fourth and Eighth Grades

For the fourth and eighth grades, each content domain includes items developed to address each of the three cognitive domains: knowing, applying and reasoning. The following sections further describe the thinking processes that define these cognitive domains. Each cognitive domain consists of a set of cognitive areas, each categorized by a verb that reflects the overarching thinking process and accompanied by a brief description. Beneath each description are expanded examples that illustrate the scope of the cognitive area, as well as how science practices and scientific ways of thinking are used in TIMSS items in each cognitive area. The examples that demonstrate specific science practices are followed by the number of the practice in parentheses.

Knowing

Items in this domain assess students' scientific knowledge (e.g., facts, relationships, processes, concepts). Accurate and broad-based factual and procedural knowledge forms a foundation that students can draw upon to successfully engage in the more complex cognitive activities essential to the scientific enterprise.

Recognize	Identify facts, relationships, objects, phenomena, and concepts; e.g.: • Identify the characteristics or properties of specific organisms, materials, and processes • Identify the appropriate uses for scientific equipment and procedures • Recognize an appropriate description of a phenomenon
Describe	Describe facts, relationships, objects, phenomena, and concepts; e.g.: • Describe properties, structures, or functions of organisms and materials • Describe relationships among organisms, materials, processes, and phenomena
Provide Examples	Provide or identify examples that meet given criteria; e.g.: • Identify examples of organisms, materials, or processes that possess certain specified characteristics • Illustrate statements of facts or concepts with appropriate examples

Applying

Items in this domain require students to engage in applying scientific knowledge (e.g., facts, relationships, processes, concepts, equipment, methods) in contexts likely to be common in the teaching and learning of science.

Compare/Contrast/ Classify	Identify or describe similarities and differences among groups; e.g.: • Make distinctions between groups of organisms, materials, or processes, based on characteristics or properties • Classify or sort objects, materials, organisms, and processes based on characteristics or properties
Relate	Relate scientific knowledge to a phenomenon or application; e.g.: • Recognize an observed or inferred property that explains the use of an object or material • Connect the behavior of organisms to the underlying scientific principle • Formulate questions that can be answered by investigation (Practice 1)
Use Models	Use a model to demonstrate knowledge of science concepts; e.g.: • Use a diagram to illustrate a process, cycle, relationship, or system • Use models to find solutions to science problems • Use models to generate data to answer a scientific question (Practice 2)
Interpret Information	Use knowledge of science concepts to interpret relevant, tabular, pictorial, and graphical information; e.g.: • Recognize patterns in information • Interpret a graph that represents a phenomenon • Interpret tabular data of a field observation (Practice 3)
Explain	Provide or identify an explanation for an observation or a phenomenon using a science concept or principle; e.g.: • Explain processes that produce changes that occur over time • Explain observations of organisms using structure and function • Explain observations using scientific knowledge (Practice 4)

Reasoning

Items in this domain require students to engage in reasoning to analyze data and other information, draw conclusions, and extend their understanding to new situations. Scientific reasoning also encompasses developing hypotheses as well as designing scientific models and investigations. In contrast to the more direct applications of science facts and concepts exemplified in the applying domain, items in the reasoning domain may involve less common or more complicated contexts or ask students to combine several facts, concepts, and processes. Answering such items can involve more than one approach or strategy.

Predict	Use scientific evidence and conceptual understanding to make predictions; e.g.: • Make predictions based on a given scenario or experimental design (Practice 1) • Formulate testable assumptions based on conceptual understanding and knowledge from experience, observation, and/or analysis of scientific information (Practice 1) • Make predictions about the effects of changes in biological or physical conditions or about the outcome of a dynamic situation
Design	Plan investigations or procedures appropriate for answering scientific questions or testing hypotheses; design models to illustrate processes; e.g.: • Develop models • Make decisions about the setup of an investigation (Practice 2) • Design a plan that applies scientific procedural principles to solve a problem (Practice 2)
Analyze/Synthesize	Answer questions that require consideration of a number of different factors or related concepts; e.g.: • Identify the elements of a scientific problem and combine them to answer a question • Combine information from multiple graphs to respond to a question • Apply information interpreted from a diagram alongside scientific understanding
Draw Conclusions	Draw appropriate conclusions that address questions or hypotheses; e.g.: • Make valid inferences on the basis of observations, evidence, and/or understanding of science concepts (Practice 4) • Answer research questions using understanding of cause and effect (Practice 4)
Evaluate	Evaluate models, results of investigations, and alternative explanations; e.g.: • Weigh advantages and disadvantages to make decisions about alternative processes and materials • Evaluate models in terms of their merits and limitations • Evaluate results of investigations with respect to sufficiency of data to support conclusions (Practice 4)
Justify	Use evidence and science understanding to support the reasonableness of explanations and conclusions; e.g.: • Defend solutions to problems • Support conclusions from investigations with experimental data (Practice 5)
Generalize	Make general conclusions that go beyond the experimental or given conditions; e.g.: • Apply conclusions of an experiment to new situations (Practice 5)

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CHAPTER 3:

TIMSS 2027 Contextual Framework

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Overview

In addition to measuring trends in students' mathematics and science achievement, TIMSS collects important information about contexts for student learning. Educational research, including previous cycles of TIMSS, has long demonstrated substantive relationships among student background, learning environments and student achievement. Broadly speaking, greater opportunities to learn and more supportive learning environments both at home and at school are consistently associated with higher mathematics and science achievement both across and within countries.

TIMSS contextual data are an important resource for research on improving mathematics and science education, and this information is used to support and characterize aspects of the TIMSS mathematics and science achievement results, as well as enabling investigation of topics related to educational equity. Some context variables have been collected for many cycles of TIMSS because of their ongoing relevance, and other indicators are added or removed each cycle to address changes in research and policy interests over time.

The TIMSS 2027 Contextual Framework describes the different types of contextual information to be collected in TIMSS 2027. Similar to previous TIMSS cycles, the framework focuses on the five areas of influence on students' mathematics and science achievement: home contexts; school contexts; classroom contexts; student characteristics, attitudes, and behaviors; and national contexts. Relationships among these sources of influence are discussed at the beginning of the Contextual Framework, which then continues with an elaboration of specific topics within each area that are included in the TIMSS 2027 context questionnaires.

TIMSS 2027 Contextual Data Collection Sources

The contextual information available in TIMSS 2027 consists of quantitative data obtained through questionnaires, as well as qualitative data collected through participants' Encyclopedia chapters. Each of these data sources is described below.

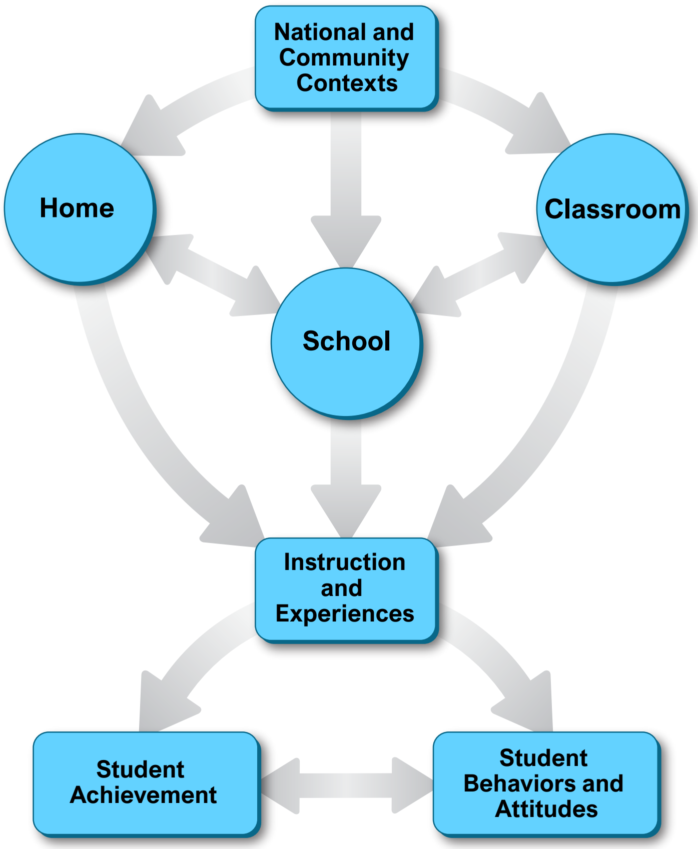
- **Student Questionnaire:** This questionnaire is completed by fourth- and eighth-grade students following the mathematics and science assessment. Two versions of this questionnaire are provided for the eighth grade: one for students who take science as an integrated subject and one for students enrolled in separate science subjects (biology, chemistry, physics, and earth science).
- **Home Questionnaire:** This questionnaire is completed by the parents or primary caregivers of the students participating in TIMSS. Previous cycles of TIMSS administered the Home Questionnaire only to parents of fourth-grade students; TIMSS 2027 also includes a Home Questionnaire for parents of eighth-grade students.
- **School Questionnaire:** This questionnaire is completed by the principal of each participating school.
- **Teacher Questionnaire**: This questionnaire is completed by students' mathematics and science teachers. There is typically one classroom teacher for fourth-grade students and separate mathematics and science teachers for eighth-grade students.
- **Curriculum Questionnaire:** This questionnaire is completed by the National Research Coordinator (NRC) for each participating country with assistance from curriculum experts as necessary.
- ***TIMSS 2027 Encyclopedia* Chapters:** Chapters are written by NRCs or other representatives of participating countries.

The Student, Home, School, and Teacher Questionnaires cover similar topics for the fourth and eighth grades, although some items may be unique to the different grade versions based on appropriateness of certain topics for primary or lower secondary school contexts. The Curriculum Questionnaire includes general items that are identical across the fourth and eighth grades, as well as items that are grade- and subject-specific. All countries follow a common outline for the Encyclopedia chapters, regardless of the grade(s) at which they participate in TIMSS 2027.

Contexts for Student Learning in Mathematics and Science

Students' academic achievement, attitudes, and behaviors must be evaluated in the context of their instructional and personal experiences. Students' experiences are shaped through a complex interaction of contexts at home, in school, in the community, and in society at large. The contexts for student learning presented in Exhibit 1 account for the complex interactions between different factors that shape students' educational experiences and outcomes, similar to the dynamic model of educational effectiveness.[1] The exhibit is not intended to show a deterministic model; rather, it provides a useful structure for thinking about how student achievement in mathematics and sciences relates to other aspects of educational experiences and systems.

Exhibit 1: Contexts for Student Learning



The upper portion of Exhibit 1 depicts the school at the center, which is shaped by inputs from the home, classroom, and broader national and community contexts. The lower portion depicts the relationship between students' achievement in mathematics and science and their corresponding behaviors and attitudes regarding these subjects. The bidirectional arrow between the boxes indicates a reciprocal relationship, meaning these areas are hypothesized to influence each other. Much research has supported this assertion, although the exact nature of this influence (including the predominant direction of causality) is unknown and may vary across national or cultural contexts.[2,3]

Data on student achievement, behaviors, and attitudes are all observed through the lens of assessments and self reports. To contextualize these, it is important to also collect data on instruction students experience in school, as well as their life experiences both in and outside of school. Mathematics and science instruction is intended to foster students' understanding of these subjects, but may also interact with and shape their thoughts and feelings about the subjects. Students' personal experiences outside of direct instruction may also play a role in the development of achievement, behaviors and attitudes.

Students' engagement with instruction and life experiences takes place in a combination of the home, school, and classroom spaces in which students spend their time. Each of these spaces draws from characteristics of those who occupy them (for example, parents, teachers, or principals), as well as broader national and community contexts.

The TIMSS 2027 Contextual Framework distills this network of relationships into five broad hierarchical areas. These areas are reflected in the questionnaires that are administered as part of

TIMSS 2027. Note that some components that are specified individually in Exhibit 1 are combined for the purposes of this discussion. The five areas are:

- National Contexts
- Home Contexts
- School Contexts
- Classroom Contexts
- Student Characteristics, Attitudes, and Behaviors

The remainder of the framework provides details about the topics related to each area that are covered in the TIMSS 2027 Context Questionnaires. Information about how TIMSS 2027 conceptualizes mathematics and science achievement can be found in the TIMSS 2027 Mathematics Framework and TIMSS 2027 Science Framework.

Home Contexts

Students' home contexts are part of their informal learning experiences and also interact with school contexts to shape their formal learning experiences. Information about students' home contexts is collected through the Student and Home Questionnaires for both fourth and eighth grade. The topics included in these questionnaires are summarized in Exhibit 2.

Exhibit 2: Summary of Home Contexts Topics and Sub-Topics

Topic	Sub-Topic	Grade(s)
Home Environment	Socioeconomic Status and Home Resources	Grade 4 & Grade 8
	Language(s) Spoken at Home	Grade 4 & Grade 8
	Family Involvement in Children's Education*	Grade 4 & Grade 8
	Children's Use of Digital Devices at Home*	Grade 4
Early Learning Experiences	Early Literacy and Numeracy Activities	Grade 4
	Early Literacy and Numeracy Skills at School Entry	Grade 4

* Indicates a new topic introduced in TIMSS 2027. Topics that are not new may have different items than in previous TIMSS cycles.

Home Environment

Socioeconomic Status and Home Resources

Socioeconomic status (SES) was found to exhibit a consistent relationship with students' academic achievement.[4,5,6] SES and resources available at home consistently display some of the strongest relationships with mathematics and science achievement in previous TIMSS cycles.[7,8] This pattern holds across a wide range of countries participating in IEA studies, and socioeconomic academic achievement gaps have grown within the past few decades.[9,10] SES is often measured through proxy variables, including parental level of education and occupation. Although there are challenges when measuring SES across cultures, parental education and occupation have been successfully used as SES indicators in a large number of surveys.[11] TIMSS 2027 complements these indicators with information about various resources for learning that are available in the home, such as the number of books, a quiet place to do schoolwork, and access to the internet and various digital devices. TIMSS 2027 collects information about home resources in the Student and Home Questionnaires.

Language(s) Spoken at Home

There are many reasons why children might not speak their school's language of instruction at home, and these reasons vary across different country contexts. For example, countries may have numerous national languages or large immigrant populations that speak a language different from the language of instruction in schools. Learning mathematics or science in a language other than the one that is primarily spoken at home can pose difficulties for students because they are learning both curricular concepts and a less familiar or unfamiliar language.[12,13] Results from previous cycles of TIMSS suggest that having at least some familiarity with the language of the assessment is associated with higher achievement, although always speaking the language of the assessment at home is not necessarily associated with the highest achievement.[14] TIMSS 2027 collects information about the language(s) students speak at home in the Student and Home Questionnaires.

Family Involvement in Children's Education

There are many ways in which parents and families can contribute to children's education, ranging from casual (for example, asking about the school day) to more involved (for example, assisting with schoolwork). Parent/family engagement with the school itself also exists along a continuum,[15] and expectations and opportunities for family involvement in school varies considerably across countries. Parents' and families' perceptions of children's schools can be affected by many factors, such as how well the school communicates about academic progress or respects families from different backgrounds.[16] TIMSS 2027 collects information about family involvement in children's education in the Student and Home Questionnaires. Information about parents' perceptions of their child's school is collected in the Home Questionnaire.

Children's Use of Digital Devices at Home

As the availability of digital devices has expanded, concerns have been raised about the impact of screen time on children. Some studies suggest that large amounts of screen time are associated with decreased academic performance and other outcomes related to children's well-being.[17] However, there is also some evidence that the relationship between screen time and academic performance differs for households of different socioeconomic status.[18] TIMSS 2027 collects information about whether parents of fourth-grade students have rules about time spent on digital devices at home in the Home Questionnaire.

Early Learning Experiences

Early Literacy and Numeracy Activities

Early childhood learning activities are often cited as having positive relationships with students' education outcomes.[19,20,21] Early numeracy activities at home may relate to later mathematics performance and to students' mathematics self-efficacy.[22] Engaging children in early numeracy activities may also relate to their interest in mathematics and the development of numeracy skills.[23,24] Data from earlier TIMSS cycles shows that many parents across countries report engaging in early literacy and numeracy activities with their children, and that doing so is positively associated with mathematics and science achievement.[25] TIMSS 2027 collects information about early literacy and numeracy activities in the fourth-grade Home Questionnaire.

Early Literacy and Numeracy Skills at School Entry

Students who enter primary school with basic literacy and numeracy skills have a stronger foundation for primary school than students who are lacking these skills. Analyses of data from previous cycles of TIMSS provide evidence for a relationship between students' abilities to perform early literacy and numeracy tasks at primary school entry are associated with higher achievement.[26] Early literacy skills may be particularly important because reading skills are required to understand many mathematics and most science questions.[27] TIMSS 2027 collects information about fourth-grade students' early literacy and numeracy skills before entering primary school in the Home Questionnaire.

School Contexts

As the formal providers of instruction, schools play an essential role in students' educational experiences. Information about students' school contexts is collected through the School, Teacher, and Home Questionnaires for both fourth and eighth grade. The topics included in these questionnaires are summarized in Exhibit 3.

Exhibit 3: Summary of School Contexts Topics and Sub-Topics

Topic	Sub-Topic	Grade(s)
School Characteristics and Composition of Student Body	School Geographic Location	Grade 4 & Grade 8
	Socioeconomic Background of Student Body	Grade 4 & Grade 8
	Language Spoken by Student Body	Grade 4 & Grade 8
	School Readiness	Grade 4
School Climate	School Safety	Grade 4 & Grade 8
	School Emphasis on Academic Success	Grade 4 & Grade 8
	School Engagement with Students' Families*	Grade 4 & Grade 8
	Teacher Job Satisfaction and Challenges	Grade 4 & Grade 8
	Resources for Mathematics and Science Instruction	Grade 4 & Grade 8
	School Emphasis on Environmental Sustainability	Grade 4 & Grade 8
School Resources and Technology	Availability of Computers and Internet	Grade 4 & Grade 8
	Policies Regarding Technology Use*	Grade 4 & Grade 8
Principal Characteristics	Qualifications and Years of Experience	Grade 4 & Grade 8
	Leadership Practices*	Grade 4 & Grade 8

* Indicates a new topic introduced in TIMSS 2027. Topics that are not new may have different items than in previous TIMSS cycles.

School Characteristics and Composition of Student Body

School Geographic Location

Schools are located in a variety of different geographical areas (e.g., urban, suburban, rural). It is not possible to make internationally applicable generalizations about the relation of school location to students' academic achievement; however, this still provides important information that characterizes students' school experiences. TIMSS 2027 collects information about schools' geographic location in the School Questionnaire.

Socioeconomic Background of Student Body

Since the publication of the Coleman report in the United States,[28] there has been sustained interest in how the socioeconomic composition of schools is related to the achievement of individual students.[29,30,31] This relationship between socioeconomic composition of schools and achievement is not necessarily uniform across countries and may be impacted by country-level factors, such as use of student tracking.[32] The mechanisms that promote socioeconomic segregation or integration across schools (e.g., school choice policies[33]) and contribute to its effects on schools are also likely to vary across countries (e.g., fundraising practices or access to highly qualified teachers).[34,35] TIMSS 2027 collects information about the socioeconomic composition of schools in the School Questionnaire.

Language Spoken by Student Body

Schools vary in their linguistic diversity, and this diversity depends on many country-specific contextual factors—for example, countries may have large immigrant populations, or it may be common practice for schooling to take place in a second language. TIMSS 2027 collects information about the percentage of students in schools who have the language of instruction as their native language in the School Questionnaire.

School Readiness

Students who enter the first grade of primary school with some literacy and numeracy skills have a stronger foundation for formal mathematics and science education. Schools where a larger proportion of students begin primary education without these skills may need to expend additional resources to enable students to effectively engage with on-grade instruction. TIMSS 2027 collects information about the percentage of students entering school with basic literacy and numeracy skills in the School Questionnaire.

School Climate

School Safety

School safety is an important variable related to student achievement in many countries and is an important factor in school climate.[36,37] Respect for individual students and teachers and a safe and orderly environment are associated with higher student achievement.[38,39] Some research suggests that schools where rules are clear and enforced fairly tend to have atmospheres of greater discipline and safety.[40] TIMSS 2027 collects information about school safety in the Teacher and School Questionnaires.

School Emphasis on Academic Success

Teaching, learning, and the organizational culture surrounding these processes are important contributors to school climate.[41] A school atmosphere of academic optimism and high expectations for academic excellence can contribute to school success.[42,43] Such an atmosphere includes an overarching emphasis on academics, collective efficacy in promoting academic performance, and trust among a school's staff, students, and parents.[44,45] TIMSS 2027 collects information about school emphasis on academic success in the School Questionnaire.

School Engagement with Students' Families

Schools can engage with students' families in a variety of ways, including regular communication (such as newsletters or emails) and hosting academic or community-building events. The ways in which schools promote family engagement may vary across country contexts. TIMSS 2027 collects information about how schools engage with students' families in the School Questionnaire.

Teacher Job Satisfaction and Challenges

Teacher job satisfaction is important for retaining qualified teachers in the classroom and promoting instructional quality.[46,47] Teachers may also encounter challenges such as large class sizes, lack of planning time, and frequent curricular changes that compromise their teaching. TIMSS 2027 collects information about teacher job satisfaction and challenges in the Teacher Questionnaire.

Resources for Mathematics and Science Instruction

Adequate facilities and sufficient instructional resources are important for maintaining favorable school learning environments.[48] Although "adequacy" of resources can be relative, the supply and quality of school resources have been shown to be critical for quality instruction, especially in less wealthy countries.[49,50] TIMSS conceptualizes school resources as both general and subject-specific, collecting information on general resources such as school building facilities and instructional space or materials, as well as resources specific to mathematics and science instruction. These subject-specific resources include teachers with specialized training in mathematics or science, relevant library resources for mathematics and science, and materials for carrying out hands-on science experiments or investigations. TIMSS 2027 collects information about school resources for teaching mathematics and science in the School Questionnaire.

School Emphasis on Environmental Sustainability

Schools are formative environments which are hypothesized to influence children's and adolescents' environmental attitudes and behaviors.[51,52] A shared vision and a schoolwide approach to sustainability education can give a clear direction to teachers and encourage collaboration for integrating sustainability in educational processes.[53, 54,55] School practices can serve as models of sustainable behavior for students as they provide examples of applying sustainability principles in everyday life; they can also provide opportunities for students to participate in environmentally responsible activities. Integrating sustainability principles in schools' everyday practices can be understood as one way of promoting environmentally sustainable attitudes and behaviors in students.[56,57] TIMSS 2027 collects information about how frequently schools engage in activities to promote environmental sustainability, as well as whether students have opportunities to participate in environmentally responsible activities at school, in the School Questionnaire.

School Resources and Technology

Availability of Computers and Internet

Increased use of computers and the internet in schools has created new opportunities for teaching and learning while simultaneously generating challenges related to access, implementation, and appropriate use.[58] Schools vary in the availability of computers for student use; some schools may provide students with individual devices, whereas others may have more traditional computer labs. TIMSS 2027 collects information about types of computer access for students, as well as internet access for students and teachers, in the School Questionnaire.

Policies Regarding Technology Use

School-level priorities and rules related to technology use are designed to influence teachers' and students' use of technology.[59] With the rapid evolution of technologies such as generative artificial intelligence, school policies on the use of these technologies can aim to influence their integration into teaching and learning. Similarly, mobile phones present challenges such as student distraction, although they may also have potential learning uses.[60] TIMSS 2027 collects information about school policies related to the use of artificial intelligence (for students and teachers) and student access to personal mobile phones at school in the School Questionnaire.

Principal Characteristics

Qualifications and Years of Experience

Principals act as leaders in schools by overseeing school staff, students, and the school environment. Some studies suggest that strong principal leadership can foster student achievement by creating an atmosphere of collective efficacy through a positive school climate and trust among teachers.[61,62] TIMSS 2027 collects information about principal years of experience and credentials in school leadership in the School Questionnaire.

Leadership Practices

Principals serve as the instructional leaders of their schools and can demonstrate instructional leadership through various practices. For example, collaborative leadership for partnerships with families and teachers includes encouraging teacher and family communication, as well as a principal's presence at school-wide events, family-teacher meetings, and activities.[63] TIMSS 2027 collects information about principals' leadership practices in the School Questionnaire.

Classroom Contexts

Students are clustered into classrooms within the schools they attend. These classroom contexts contribute to student achievement by shaping students' learning experiences. Important classroom-level factors include teacher characteristics, instructional methods, access to technology, and classroom climate. Information about students' classroom contexts is collected through the Teacher and Student Questionnaires for both fourth and eighth grade. The topics included in these questionnaires are summarized in Exhibit 4.

Exhibit 4: Summary of School Contexts Topics and Sub-Topics

Topic	Sub-Topic	Grade(s)
Teacher Characteristics and Qualifications	Demographic Information	Grade 4 & Grade 8
	Preparation and Years of Experience	Grade 4 & Grade 8
	Teachers' Instructional Challenges	Grade 4 & Grade 8
Mathematics and Science Instruction	Instructional Time	Grade 4 & Grade 8
	Instructional Strategies	Grade 4 & Grade 8
	Frequency of Experiments and Inquiry-Based Activities	Grade 4 & Grade 8
	Emphasis on Environmental Sustainability	Grade 4 & Grade 8
	TIMSS Mathematics and Science Topics Taught	Grade 4 & Grade 8
	Homework	Grade 4 & Grade 8
Information Technology	Computer Use During Instruction	Grade 4 & Grade 8
	Use of Generative Artificial Intelligence Tools*	Grade 4 & Grade 8
Classroom Climate and Instructional Quality	Instructional Clarity and Supportive Classroom	Grade 4 & Grade 8
	Cognitive Activation	Grade 4 & Grade 8
	Classroom Disruptions	Grade 4 & Grade 8
	Factors Limiting Instruction	Grade 4 & Grade 8

* Indicates a new topic introduced in TIMSS 2027. Topics that are not new may have different items than in previous TIMSS cycles.

Teacher Characteristics and Qualifications

Demographic Information

TIMSS 2027 collects basic information about teacher demographics (age, gender) in the Teacher Questionnaire.

Preparation and Years of Experience

Quality teacher preparation is critical for effective teaching and can serve as a moderator for the relationship of other variables with student achievement.[64,65] Some studies suggest that teachers' subject-specific knowledge has a positive relationship with student achievement in conjunction with their pedagogical skills.[66] Teaching experience is also important for teacher development, especially in the early years of teaching.[67,68] Requirements for teacher preparation and specialization vary across countries—whereas fourth-grade students are often taught by generalist teachers, eighth-grade students are more likely to be taught by subject-specialist teachers.[69] TIMSS 2027 collects information about teacher preparation and years of experience in the Teacher Questionnaire.

Teachers' Instructional Challenges

Teachers employ a variety of skills and knowledge to provide mathematics and science instruction and experience different degrees of challenge in doing so. Pedagogical content knowledge is a useful concept for characterizing these qualities—although there are many variations of the concept, it generally comprises teachers' knowledge related to the subject they teach, as well as good practices for fostering student learning in the subject.[70] TIMSS 2027 collects information about teachers' challenges enacting different aspects of PCK in their instruction in the Teacher Questionnaire.

Mathematics and Science Instruction

Instructional Time

Instructional time in mathematics and science is an important aspect of curriculum implementation. Increased instructional time tends to be positively related to student achievement, although such relationships depend on how effectively instructional time is used.[71,72] That is, increased instructional time is likely to have a greater impact on student achievement for students with more highly qualified teachers.[73] TIMSS 2027 collects information about mathematics and science instructional time in the Teacher Questionnaire.

Instructional Strategies

Teachers vary in their instructional strategies, both internationally and within countries.[74] Effective mathematics instruction can include practices such as asking students to explain their answers or purposefully practice mathematical procedures.[75,76] While there is general consensus that not all mathematics instruction should be devoted to memorization, automaticity of basic mathematical facts (i.e., the ability to answer a problem quickly without calculation[77]) assists students in learning more complex mathematics material.[78] Hands-on activities and experiments can be helpful in promoting students' understanding of science, although research suggests that these activities should be appropriately scaffolded and supported.[79,80] TIMSS 2027 collects information about instructional strategies for mathematics and science in the Teacher Questionnaire.

Frequency of Experiments and Inquiry-Based Activities

Student inquiry is an important component of science education; however, its relationships with academic achievement are complex.[81] Increased frequency of experiments or investigations is not necessarily associated with increased science achievement.[82] Quality of inquiry-based activities may be more important—high quality inquiry activities can include asking students to articulate research questions or hypotheses, create models and explanations, and effectively communicate results of investigations.[83] TIMSS 2027 collects information about experiments and science inquiry in the Student and Teacher Questionnaires.

Emphasis on Environmental Sustainability

Studies suggest that teaching methods vary in their effectiveness at providing quality instruction on environmental sustainability topics. Students who experience more active and interactive teaching methods (e.g., classroom discussions, research projects, excursions in nature) may have greater awareness of environmental issues, more positive environmental attitudes, and more frequent environmentally responsible behavior.[84] Effective teaching that promotes education for sustainable development includes acknowledgement of the interconnected aspects of sustainability (i.e., environmental, social, and economic) and engages students in real-world problem-solving activities.[85] TIMSS 2027 collects information about how often teachers use different strategies to teach about environmentalism and sustainability in the Teacher Questionnaire.

TIMSS Mathematics and Science Topics Taught

"Opportunity to learn" refers to whether students have been exposed to particular topics in mathematics and science; students may demonstrate poorer performance if they have not been taught assessment content.[86] Although opportunity to learn does not provide a complete picture of how students experience curricula,[87] it can still account for some differences in student achievement. TIMSS 2027 collects information about whether students have been taught the mathematics and science topics included in the TIMSS assessment in the Teacher Questionnaire.

Homework

Assignment of homework in mathematics and science varies both within and across countries. The relationship between time spent on homework, types of homework assigned, and student achievement is not straightforward and may vary depending upon a particular country's context and policies.[88,89] Teachers may assign homework for different purposes, including practicing skills taught in class or previewing topics in upcoming lessons.[90] TIMSS 2027 collects information about the purposes of mathematics and science homework in the Teacher Questionnaire.

Information Technology

Computer Use During Instruction

Within and across countries, schools and classrooms vary in access to devices such as computers and tablets, although use of digital devices in classrooms has increased over time, especially following the COVID-19 pandemic. Over the 2015, 2019, and 2023 cycles, TIMSS data have shown a steady increase in the percentage of students whose mathematics and science teachers report that students have access to digital devices during instruction. Some research has shown that performing classroom activities, such as notetaking on computers is associated with lower achievement than doing so on paper.[91] Much of the research in this area is focused on university-level students, although there is also some support that taking notes on paper is associated with improved conceptual understanding in science for younger students.[92] TIMSS 2027 collects information about whether students use computers or paper-and-pencil more often for routine classroom activities in the Teacher Questionnaire.

Use of Generative Artificial Intelligence Tools

Generative artificial intelligence is a rapidly evolving field, and it is not possible to make definitive claims about its impact on student learning in mathematics and science. However, there is evidence that teachers use artificial intelligence for a variety of purposes.[93,94] TIMSS 2027 collects information about teacher use of generative artificial intelligence for teaching-related activities in the Teacher Questionnaire.

Classroom Climate and Instructional Quality

Instructional Clarity and Supportive Classroom

Instructional clarity and a supportive classroom environment are two concepts that relate to students' perceptions of their teachers' instructional strategies and are important components of instructional quality. Teachers with a high degree of instructional clarity provide straightforward explanations of content and effectively monitor student understanding, employing a variety of pedagogical techniques as required.[95,96] Teachers who establish a supportive classroom environment engage in practices such as providing helpful feedback, clearly addressing student questions, and encouraging struggling students.[97] Several studies using TIMSS data related to these topics from previous cycles have found positive associations between instructional clarity and student achievement.[98,99,100] There is also some for a positive association between a supportive classroom climate and student achievement.[101] TIMSS 2027 collects information about students' perceptions of instructional clarity and supportive classroom climate in the Student Questionnaire.

Cognitive Activation

Cognitive activation is another important component of instructional quality and refers to the degree to which students are appropriately challenged during mathematics or science lessons.[102] These challenges can include activities such as explaining answers to questions, using knowledge in new situations, and applying mathematics or science knowledge to solve everyday problems. TIMSS 2027 collects information about the frequency of cognitively challenging activities in mathematics and science lessons in the Student and Teacher Questionnaires.

Classroom Disruptions

Classroom disruptions can be detrimental to student learning, as they reduce time spent on curricular content and negatively affect the classroom climate. Classroom management refers to non-instructional procedures put in place by teachers that promote student learning and discourage disruptive behavior and is an important component of instructional quality.[103,104] Direct links between classroom management, disruptive behavior, and student achievement are difficult to establish, but some research suggests that effective classroom management is positively related to student achievement.[105,106,107] TIMSS 2027 collects information about students' perceptions of classroom disruptions and management in the Student Questionnaire.

Factors Limiting Instruction

There are various school- and student-level factors that can limit the effectiveness of mathematics or science instruction within the classroom. School-level factors include responsibility for teaching too many students, lack of preparation time, or frequent curriculum changes. Student factors can be directly related to academic preparedness (such as a lack of prerequisite knowledge or skills), well-being (such as lack of basic nutrition or frequent absences), or behavior in the classroom (such as distraction or disruption). These factors can not only limit teachers' abilities to provide effective instruction but may also relate to student achievement. For example, research suggests that students lacking basic nutrition tend to have lower academic achievement.[108,109] Frequent absences limit students' opportunities to learn and participate in mathematics or science lessons, and some research suggests that student absences have increased since the COVID-19 pandemic, although this likely varies across countries.[110] TIMSS 2027 collects information about school- and student-level factors that potentially limit instruction in the Teacher and Student Questionnaires.

Student Characteristics, Attitudes, and Behaviors

Many student-level attributes that may contribute to mathematics and science achievement, including experiences at school and student attitudes towards the subjects. Some attributes, such as liking and valuing mathematics and science, may also be considered independent goals of education. It is important to acknowledge the link between students' attitudes and behaviors; in addition to being related to achievement, these are also likely to be related to each other. TIMSS 2027 collects information about these topics in the Student Questionnaire for both Grades 4 and 8. The topics included in these questionnaires are summarized in Exhibit 5.

Exhibit 5: Summary of Student Characteristics, Attitudes, and Behaviors Topics and Sub-Topics

Topic	Sub-Topic	Questionnaire Grade(s)
Student Demographics		Grade 4 & Grade 8
Student Experiences at School	School Belonging	Grade 4 & Grade 8
	Bullying	Grade 4 & Grade 8
Student Attitudes Toward Mathematics and Science	Liking Mathematics and Science	Grade 4 & Grade 8
	Valuing Mathematics and Science**	Grade 4 & Grade 8
	Confidence in Mathematics and Science	Grade 4 & Grade 8
Student Use of Information and Communications Technology (ICT)	Computer Use for Schoolwork	Grade 4 & Grade 8
	Use of Artificial Intelligence for Schoolwork*	Grade 4 & Grade 8
Students' Environmental Attitudes and Behaviors	Valuing Environmental Preservation	Grade 4 & Grade 8
	Efficacy for and Enactment of Environmentally Responsible Behaviors	Grade 4 & Grade 8

* Indicates a new topic introduced in TIMSS 2027. Topics that are not new may have different items than in previous TIMSS cycles.

** New for Grade 4.

Student Demographics

Information about students' demographic characteristics allows for exploration of achievement gaps between different groups of students. Student gender may be of particular interest for this purpose, as many countries show achievement gaps between boys and girls in mathematics and science.[111] Student age also relates to student achievement: In countries where students enter primary school strictly based on age, older students may have more advanced skills than younger students because of maturation. However, depending on retention policies, older students who have repeated a grade may struggle more academically than their younger peers. TIMSS 2027 collects information about student demographics in the Student Questionnaire.

Student Experiences at School

School Belonging

Students' sense of school belonging has been found to contribute to general well-being and academic achievement.[112,113] Sense of school belonging is shaped by how students perceive themselves and their relationships with others (teachers, other students, etc.) within the school, as well as their relationship with the school community itself.[114] These social connections are an important component of student well-being at school.[115] TIMSS 2027 collects information about students' sense of school belonging in the Student Questionnaire.

Bullying

Bullying involves repeated aggressive behavior intended to intimidate or harm students. Bullying can take a variety of forms and can occur in person or virtually. Individuals who would not bully others in person may be more likely to do so online because of online disinhibition.[116] However, there is an association between experiencing bullying online and in person.[117] Research using data from previous cycles of TIMSS has shown evidence that reports of experiencing frequent bullying is associated with lower academic achievement, and students who report being bullied most frequently have substantially lower achievement than their peers.[118,119] TIMSS 2027 collects information about students' experiences of bullying behaviors in the Student Questionnaire.

Student Attitudes Toward Mathematics and Science

Liking Mathematics and Science

Students who enjoy mathematics and science find the subjects interesting and are likely to be more intrinsically motivated in mathematics and science classes. Intrinsic motivation is a predictor of behavior,[120] and encourages students to pursue a subject they find interesting and enjoy learning.[121,122] Students who report liking mathematics and science tend to have higher achievement and be more likely to choose courses in these subjects later in schooling than those who report lower levels of liking the subjects.[123,124] These relationships can be reciprocal; students who do well in mathematics and science may be more likely to have positive attitudes towards the subjects.[125] TIMSS 2027 collects information about students' liking of mathematics and science in the Student Questionnaire.

Valuing Mathematics and Science

In contrast to intrinsic motivation, extrinsic motivation refers to motivation that is inspired by a separate outcome from the activity itself.[126] Students who are extrinsically motivated to learn mathematics and science may value the subjects because of future opportunities, such as entrance into desirable educational programs or a well-paying career. Students may also be extrinsically motivated by the desire to impress or help others.[127] Some research suggests that such motivation is associated with choosing science courses later in schooling, particularly for students from disadvantaged backgrounds.[128] Additionally, students who articulate an interest in science careers in primary or early secondary school are more likely to actually pursue those careers.[129] TIMSS 2027 collects information about students' valuing of mathematics and science in the Student Questionnaire.

Confidence (Self-Concept) in Mathematics and Science

Self-concept (or confidence, as traditionally named in TIMSS) is domain-specific and relates to how students view their abilities in different subjects.[130] Students' self-appraisal of their abilities in a given subject are often based on past experiences and how they see themselves compared with their peers.[131] Students who are confident in a particular subject persevere through challenging material because they believe they will ultimately succeed.[132] Additionally, anxiety or a lack of confidence in a subject is associated with lower achievement.[133,134] As with liking, confidence and achievement in academic subjects may have a reciprocal relationship. TIMSS 2027 collects information about student confidence in mathematics and science in the Student Questionnaire.

Student Use of Information and Communications Technology (ICT)

Computer Use for Schoolwork

Students vary in their use of computers, both at home and in school.[135] Computers can be used for a variety of school tasks, including writing text, creating presentations, and working with data. TIMSS 2027 collects information about how often students use computers for different school-related tasks in the Student Questionnaire.

Artificial Intelligence Use for Schoolwork

Student use of generative artificial intelligence (AI) for school-related tasks is an area of emerging interest; little is currently known about how frequently students use these types of tools, especially younger students. TIMSS 2027 collects information about how often students use AI for schoolwork in the Student Questionnaire.

Students' Environmental Attitudes and Behaviors

Valuing Environmental Preservation

The degree to which students value the natural environment may relate to their enactment of environmentally responsible behaviors. Valuing environmental preservation is a component of the Theory of Ecological Attitude.[136,137] Valuing environmental preservation reflects a tendency to endorse the conservation and preservation of nature. Students with preservation-oriented attitudes are likely to enjoy spending time in nature and care about the protection of natural areas. TIMSS 2027 collects information about students' attitudes towards environmental preservation in the Student Questionnaire.

Efficacy for and Enactment of Environmentally Responsible Behaviors

Practicing environmentally responsible behaviors is related to many factors, including attitudes, knowledge, and opportunities and circumstances.[138,139] The agency that children have to make consequential decisions, and their ability to exercise control over different aspects of their environments, likely varies across countries, cultures, and households.[140] Action competence is one framework for considering such behaviors and conceptualizes action for sustainable development as being driven by knowledge, willingness, and efficacy to act in solving challenging problems.[141] TIMSS 2027 focuses on the efficacy component of this framework, which emphasizes children's ability to engage in environmentally responsible behaviors. TIMSS 2027 collects information about students' efficacy to enact environmentally responsible behaviors, as well as whether they engage in the behaviors, in the Student Questionnaire.

National Contexts

Students' families, classrooms, and schools are all situated within broader national contexts. Country-level policies about the organization of the education system and mathematics and science curricula are important contributors to students' experiences and learning. All information about national contexts in TIMSS 2027 is collected in the Curriculum Questionnaire, the general contents of which are summarized in Exhibit 6. This information is also complemented by countries' chapters in the *TIMSS 2027 Encyclopedia*.

Exhibit 6: Summary of National Contexts Topics and Sub-Topics

Topic	Sub-Topic
Organization of Education System	Number of Years of School
	Age of Entry and Retention Policies
	System for Preprimary Education
	Language(s) of Instruction
	Teacher and Principal Preparation
Mathematics and Science Curricula	Curriculum Specifications
	Instructional Materials and Use of Digital Devices
	TIMSS Assessment Topics Covered in the Curriculum

Topics may have different items than in previous TIMSS cycles.

Organization of the Education System

Number of Years of School

Although only fourth- and eighth-grade students participate in TIMSS, these grades are situated within a sequence of schooling that shapes the national context in which students learn. For this reason, TIMSS collects data on the years of education that are nationally mandated and provided.

Age of Entry and Retention Policies

Because TIMSS assesses students in the grades corresponding to the fourth and eighth years of formal schooling, policies about the age of entry into formal education (first year of primary school, ISCED Level 1) are important for understanding variation in achievement and students' ages within those grades across countries.[142] Countries' promotion and retention policies during different phases of schooling are also collected; research has shown that retention has negative relationships with student well-being and achievement, particularly in the short term.[143,144,145]

System for Preprimary Education

Even before they begin formal primary school, children are exposed to literacy, numeracy, and science as part of their preprimary educational experiences (e.g., preschool, kindergarten). Preprimary education is an area of investment for many countries. Research suggests that attending preprimary programs relates to positive later academic outcomes and that this relationship depends on the quality of the preprimary program.[146,147,148] The TIMSS Curriculum

Questionnaire gathers information on the different types of early childhood and preprimary education available within countries, which contextualizes the student-level information collected in the Home Questionnaire.

Language(s) of Instruction

Some countries have one commonly spoken language, while others are historically multilingual. Immigration has also increased the language diversity in many countries over time. TIMSS collects data on any official languages of instruction, as well as if mathematics and science instruction is typically presented to students in their native language.

Teacher and Principal Preparation

Information about the preparation of the teachers and principals whose students participate in TIMSS is collected through the Teacher and School Questionnaires; this is complemented by information on the most typical preparation routes for teachers and principals within each country.

Mathematics and Science Curricula

Curriculum Specifications

Whether created at the national, provincial, community, or school level, curricular documents define and communicate the curriculum that specifies expectations for students, in terms of the knowledge, skills, and attitudes to be developed or acquired through their formal mathematics and science education. Mathematics and science curricula differ across countries and are constantly evolving, although there is some evidence of curricular convergence over time.[149] In mathematics, countries differ in the degree of emphasis placed on acquiring basic skills; memorizing rules, procedures, or facts; understanding mathematical concepts; applying mathematics to real life situations; and communicating or reasoning mathematically. In science, countries vary in the extent to which they focus on acquiring basic science facts, application of science concepts, formulating hypotheses and carrying out scientific investigations, and communicating scientific explanations.

Instructional Materials and Use of Digital Devices

Country policies vary regarding the selection of instructional materials and incorporation of digital devices into mathematics and science instruction. As access to computers continues to increase, many countries' curricula include explicit statements or guidance about their use in mathematics and science instruction.[150]

TIMSS Assessment Topics Covered in the Curriculum

Particular topics and skills are introduced at different points in the mathematics and science curricula of different countries. TIMSS 2027 collects information on countries' coverage of the mathematics and science topics articulated in the TIMSS 2027 Mathematics Framework and TIMSS 2027 Science Framework. Such information is essential for contextualizing the performance of each country's students on the TIMSS assessment.

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CHAPTER 4:

TIMSS 2027 Assessment Design

Liqun Yin
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Overview

TIMSS has been conducted every four years since 1995, assessing two student populations in mathematics and science. With each assessment designed to link to the one that preceded it, TIMSS provides regular and timely trend data for educators and policymakers that can be used to inform evidence-based decisions for improving educational policy and practice. For countries that have participated since its inception, TIMSS now provides trend data covering 32 years.

In each cycle, TIMSS aims to assess student achievement in mathematics and science in a way that represents the breadth and richness of these subjects as they are taught across participating countries. It also seeks to monitor educational progress by facilitating the analysis of trends in student performance from one assessment cycle to the next. Given the diversity of curricula and student ability levels within and across participating countries, and evolving curricular expectations over time, TIMSS requires assessments that span a wide range of topics and item difficulty levels. To achieve these goals, TIMSS uses an innovative measurement approach.

The TIMSS 2027 assessment design builds on the key features of the group adaptive design introduced in TIMSS 2023 and leverages the enhanced adaptability of digital-based assessments to further reduce the mismatch between item difficulty and student ability at the group and individual levels. At the group level, the TIMSS 2027 adaptive design organizes the assessment blocks by difficulty level—difficult, medium, and easy—and combines these blocks into more and less difficult test forms. While each country administers all the test forms, the sampling proportions of more and less difficult forms can vary with the expected mathematics and science achievement levels of the students in each country.

To further improve measurement accuracy, particularly for those at the lower end of the proficiency distribution, TIMSS 2027 includes four new blocks at each grade level: two very easy mathematics blocks and two very easy science blocks. These blocks are intended for students who struggle to respond correctly to items in the initial part of their assigned test form. With this feature, the TIMSS 2027 assessment design aims to measure students' achievement more precisely, while limiting changes to the design and ensuring that trend can be reported with the same level of confidence as in past cycles of TIMSS.

Student Population Assessed

TIMSS assesses the mathematics and science achievement of students in their fourth and eighth years of formal schooling. Participating countries may choose to assess one or both populations, according to their policy priorities and resource availability.

TIMSS defines the target populations as students in the fourth and eighth years of schooling according to the International Standard Classification of Education[1] developed by the UNESCO Institute for Statistics. The ISCED classification provides an international standard for describing levels of schooling across countries, from early childhood education (level 0) to doctoral or equivalent level study (level 8).

The target populations for TIMSS are defined as follows:

- Grade 4: the grade that represents four years of schooling, counting from the first year of ISCED Level 1.
- Grade 8: the grade that represents eight years of schooling, counting from the first year of ISCED Level 1.

ISCED Level 1 corresponds to primary education and is the first stage of formal schooling. The target grade of the fourth grade for the TIMSS assessment is typically the fourth grade in most countries. Similarly, the target grade of the eighth grade for TIMSS is the eighth grade in most countries and usually corresponds to ISCED Level 2, or lower secondary education. However, given the cognitive demands of the assessments, TIMSS aims to avoid assessing very young students. Thus, TIMSS recommends that countries assess at the fifth grade if the average age in fourth grade at the time of testing is less than 9.5 years, and at the ninth grade if the average age in eighth grade is less than 13.5 years.

Reporting Student Achievement

The TIMSS assessment is designed to provide a comprehensive picture of the mathematics and science achievement of fourth- and eighth-grade students in each participating country. It is also designed to report student achievement in each of the content and cognitive domains described in Chapters 1 and 2 of this document.

One of the major strengths of TIMSS is the ability to report trends over time in mathematics and science achievement. Careful and gradual modification to the assessment design, preserves the links between successive administrations, ensuring comparable data from each of the nine TIMSS cycles from 1995 through 2027. This enables countries to measure changes in student achievement from one cycle to another. Additionally, though the scales for each grade were established separately and are not directly comparable, countries that participate in successive cycles of TIMSS can compare their relative performance of the cohort tested at the fourth grade in one cycle with the same cohort's performance in eighth grade in the next cycle.

The mathematics and science achievement scales at each grade were established by the first TIMSS administration cycle in 1995, and subsequent assessment results have been linked through successive concurrent calibrations between adjacent assessment cycles. Each scale's midpoint of 500 represents the average of the international achievement distribution for that cycle, with 100 points on the scale equivalent to one standard deviation of the distribution. Following data collection, student responses to the items in each assessment are analyzed, and proficiency estimates on the TIMSS mathematics and science scale metrics are generated, to provide a comprehensive picture of the distribution of student achievement for each country.

Construct Coverage

A key goal of the TIMSS assessment is to broadly cover the constructs being measured. This requires far more test items than any single student can answer within a reasonable time. To address this challenge, TIMSS employs a multiple-matrix sampling approach that groups the items into blocks, then assembles the blocks into test forms; each student is presented with only one of 14 possible test forms.

At each grade level, the entire pool of items is grouped into 14 mathematics blocks and 14 science blocks. These blocks are an exhaustive and mutually exclusive organization of items, with approximately 10–14 items in each block at the fourth grade and 12–18 at the eighth grade. Each block includes items from different content and cognitive domains. Of the 14 blocks per subject, eight are trend blocks that were administered in a prior assessment, and six are new blocks that were selected from the field test. The linkage through the trend blocks enables comparison of results between successive TIMSS cycles.

TIMSS 2027 Group Adaptive Design

Since 2015, TIMSS assessment designs have offered options to tailor item difficulty to student ability with the goal of providing more precise measurement for students at the lower end of the achievement distribution in mathematics.[2,3] For TIMSS 2023, an integrated group adaptive assessment design was introduced in mathematics and science,[4,5] enabling a broader range of item difficulties and more precise targeting across all student ability levels.

The TIMSS 2027 design retains the key aspects of the TIMSS 2023 group adaptive design while maintaining the 14-block structure that was first implemented in TIMSS 2007. This design requires grouping the blocks into three difficulty levels—easy, medium, and difficult—with five easy, four medium, and five difficult blocks per subject and grade.

Block Difficulty Level

For the group adaptive design to be effective, there must be distinctive differences in the average difficulties of the blocks.[6] The difficulty goals for TIMSS in terms of average percent correct across participating countries are 40 percent for the difficult blocks, 55 percent for the medium blocks, and 70 percent for the easy blocks. New blocks developed for TIMSS 2027 will aim to achieve these difficulty levels, but the existing trend blocks, especially the trend blocks developed before TIMSS 2023, can only be assigned as-is to the closest difficulty level.

As described in the previous section, for each subject and grade, eight of the 14 blocks are trend blocks carried over from TIMSS 2023, and six are new blocks composed of items selected from the field test. Of the eight trend blocks, three are difficult, two are medium, and three are easy. For the six new blocks, two are developed to meet each of the three difficulty levels. As shown in Exhibit 1, the difficulties of the existing trend blocks align closely with the three target difficulty levels for both subjects at the fourth grade. At the eighth grade, the existing trend blocks are generally more difficult than the long-term target difficulty goal for all three levels in both subjects. However, by combining these existing blocks with newly developed blocks designed to be closer to the target difficulties, progress is made toward achieving the long-term goals for the three distinct difficulty groups. As shown in the last column of Exhibit 1, the expected difficulties for 2027, after combining the existing blocks and new blocks, are approaching the long-term targets of each difficulty level— 40 percent, 55 percent, and 70 percent, respectively.

Exhibit 1: Average Difficulties of Existing Trend Blocks from 2023 and Expected Difficulties for 2027 (Average Percent Correct)

Subject	Block Difficulty Level	Empirical Difficulty of Trend Blocks from 2023	Expected Difficulty for 2027
Fourth Grade Mathematics	Difficult	40%	40%
	Medium	53%	54%
	Easy	71%	71%
Fourth Grade Science	Difficult	40%	40%
	Medium	53%	54%
	Easy	68%	69%
Eighth Grade Mathematics	Difficult	32%	35%
	Medium	41%	48%
	Easy	62%	65%
Eighth Grade Science	Difficult	37%	38%
	Medium	49%	52%
	Easy	62%	65%

Block Identification

To facilitate the later assignment of the blocks to test forms, each trend and new block is assigned a slot with a unique TIMSS 2027 block ID corresponding to its difficulty level. Each block label starts with M for mathematics or S for science, followed by D, M, or E to indicate the difficulty level (difficult, medium, or easy). Trend blocks from TIMSS 2023 are relabeled in TIMSS 2027 to differentiate them from the new 2027 block IDs while maintaining their original identity. The trend block labels begin with T23, followed by either A or B to indicate the grade level. The remainder of the block label follows the naming conventions used in the TIMSS 2023 assessment design. The oldest blocks (i.e., those developed in 2019) will be retired after the TIMSS 2027 administration.

Exhibits 2 and 3 show how the existing trend blocks fit into the subject-by-difficulty-level scheme at the fourth grade and eighth grade, respectively, and where the new blocks belong.

Exhibit 2: Subject and Difficulty Level for TIMSS 2027 Fourth-Grade Blocks

Subject	Difficulty Level	TIMSS 2027 Block ID	TIMSS 2023 Trend Block Label*
Mathematics	Difficult	MD1	T23A_MD3 (23)
		MD2	T23A_MD1 (19)
		MD3	New block for 2027
		MD4	T23A_MD5 (23)
		MD5	New block for 2027
	Medium	MM1	New block for 2027
		MM2	T23A_MM1 (23)
		MM3	New block for 2027
		MM4	T23A_MM3 (19)
	Easy	ME1	T23A_ME1 (23)
		ME2	New block for 2027
		ME3	T23A_ME3 (23)
		ME4	T23A_ME5 (23)
		ME5	New block for 2027
Science	Difficult	SD1	T23A_SD3 (23)
		SD2	T23A_SD1 (19)
		SD3	New block for 2027
		SD4	T23A_SD5 (23)
		SD5	New block for 2027
	Medium	SM1	New block for 2027
		SM2	T23A_SM1 (23)
		SM3	New block for 2027
		SM4	T23A_SM3 (19)
	Easy	SE1	T23A_SE1 (23)
		SE2	New block for 2027
		SE3	T23A_SE3 (23)
		SE4	T23A_SE5 (23)
		SE5	New block for 2027

* The number in parentheses is the assessment year in which the block was first introduced.

Exhibit 3: Subject and Difficulty Level for TIMSS 2027 Eighth-Grade Blocks

Subject	Difficulty Level	TIMSS 2027 Block ID	TIMSS 2023 Trend Block Label*
Mathematics	Difficult	MD1	T23B_MD3 (23)
		MD2	T23B_MD1 (19)
		MD3	New block for 2027
		MD4	T23B_MD5 (23)
		MD5	New block for 2027
	Medium	MM1	New block for 2027
		MM2	T23B_MM1 (23)
		MM3	New block for 2027
		MM4	T23B_MM3 (19)
	Easy	ME1	T23B_ME1 (23)
		ME2	New block for 2027
		ME3	T23B_ME3 (23)
		ME4	T23B_ME5 (23)
		ME5	New block for 2027
Science	Difficult	SD1	T23B_SD3 (23)
		SD2	T23B_SD1 (19)
		SD3	New block for 2027
		SD4	T23B_SD5 (23)
		SD5	New block for 2027
	Medium	SM1	New block for 2027
		SM2	T23B_SM1 (23)
		SM3	New block for 2027
		SM4	T23B_SM3 (19)
	Easy	SE1	T23B_SE1 (23)
		SE2	New block for 2027
		SE3	T23B_SE3 (23)
		SE4	T23B_SE5 (23)
		SE5	New block for 2027

* The number in parentheses is the assessment year in which the block was first introduced.

Test Form Design

In TIMSS 2027, the 14 mathematics and 14 science blocks at each grade are arranged into 14 test forms. Each form contains two mathematics blocks and two science blocks. To provide a mechanism for comparing student responses across different forms, each item block appears in two of the 14 test forms. Exhibit 4 illustrates the block pairings and sequence that make up each test form. The pairing pattern is identical at both grades. When blocks of different difficulties are paired in the same form, the easier block always comes first. Because each form consists of two mathematics and two science blocks, the same matching pairs of mathematics and science blocks appear in the same form. For example, blocks ME1 and MM1 appear in the same form as their science counterparts SE1 and SM1.

Exhibit 4: Block Pairings for Each Test Form

Subject	Difficult Blocks	Medium Blocks	Easy Blocks
Mathematics	MD1	MM1	ME1
	MD2	MM2	ME2
	MD3	MM3	ME3
	MD4	MM4	ME4
	MD5	—	ME5
Science	SD1	SM1	SE1
	SD2	SM2	SE2
	SD3	SM3	SE3
	SD4	SM4	SE4
	SD5	—	SE5

The 14 test forms at each grade are classified into two levels of difficulty:

- More difficult forms (7) composed of either two difficult blocks, or one medium and one difficult block, for each subject;
- Less difficult forms (7) composed of either two easy blocks, or one easy and one medium block, for each subject.

Exhibit 5 displays the block assignments for the 14 test forms, with forms 1–7 being the more difficult and forms 8–14 the less difficult ones. Half of the 14 test forms contain two mathematics blocks in Part 1, while the other half contain two mathematics blocks in Part 2. The same distribution applies to the science blocks. The block assignments are identical for both grades.

Exhibit 5: Test Forms with Block Assignments

Student Assessment Forms		Part 1		Part 2	
More Difficult Forms	Form 1	SM1	SD1	MM1	MD1
	Form 2	MD2	MD3	SD2	SD3
	Form 3	SM2	SD2	MM2	MD2
	Form 4	MD5	MD1	SD5	SD1
	Form 5	SM3	SD3	MM3	MD3
	Form 6	MM4	MD4	SM4	SD4
	Form 7	SD4	SD5	MD4	MD5
Less Difficult Forms	Form 8	ME1	MM1	SE1	SM1
	Form 9	SE1	SE2	ME1	ME2
	Form 10	ME2	MM2	SE2	SM2
	Form 11	SE3	SE5	ME3	ME5
	Form 12	ME3	MM3	SE3	SM3
	Form 13	SE4	SM4	ME4	MM4
	Form 14	ME5	ME4	SE5	SE4

The assignment of forms to students is carried out following a systematic random assignment process where forms are assigned sequentially, using different probabilities of selection for the more difficult forms and the less difficult forms.

Test Form Assignment within Countries

To ensure that the same set of assessment items is administered in every country, all 14 forms in the TIMSS 2027 are distributed in every country, but with varying proportions. The proportion of the more and less difficult forms varies depending on the expected average mathematics and science achievement of the student population. This expectation is based on performance in prior TIMSS assessments, or performance in the field test for countries participating for the first time. Higher performing countries administer proportionally more of the more difficult forms, while lower performing countries administer proportionally more of the less difficult forms. This assignment is to improve the match between assessment difficulty and student ability in each country and maximize the information obtained from the assessment.

Exhibit 6 illustrates the differential test form assignment plan for higher, middle, and lower performing countries. As a general objective, countries with expected higher average achievement scores, above 550 on the TIMSS mathematics and science achievement scales, would assign proportionally more of the more difficult forms (e.g., 70%) and fewer of the less difficult forms (30%). Countries with expected achievement scores between 450 and 550 would assign equal proportions of the more and less difficult forms. Countries with expected lower average achievement scores, below 450 on the TIMSS mathematics and science achievement scales, would assign proportionally fewer of the more difficult forms (30%) and more of the less difficult forms (70%).

Exhibit 6: Test Form Assignment Plan for Higher, Middle, and Lower Performing Countries

While the target difficulties for the blocks and forms have not been fully met, particularly at the eighth-grade level, the objective for the 2027 design is to come closer to these targets. Typically, countries participating in TIMSS 2027 will assign similar proportions of the more and less difficult forms as they did in TIMSS 2023. However, countries with average achievement above 600 could assign even higher proportions of the more difficult forms (e.g., 90%), and countries with average achievement below 350 could assign higher proportions of the less difficult forms.

Although the TIMSS 2027 group adaptive design was developed to provide a better match between test difficulty and student ability at the overall country level, it was also possible to apply the group adaptive approach for subgroups within a country, provided the country has clearly defined and identifiable subpopulations that differ from the rest of the country in terms of average student achievement. The implementation of such an adaptive design within a country needs to be coordinated with the sampling team to ensure proper selection and representation of the different types of schools.

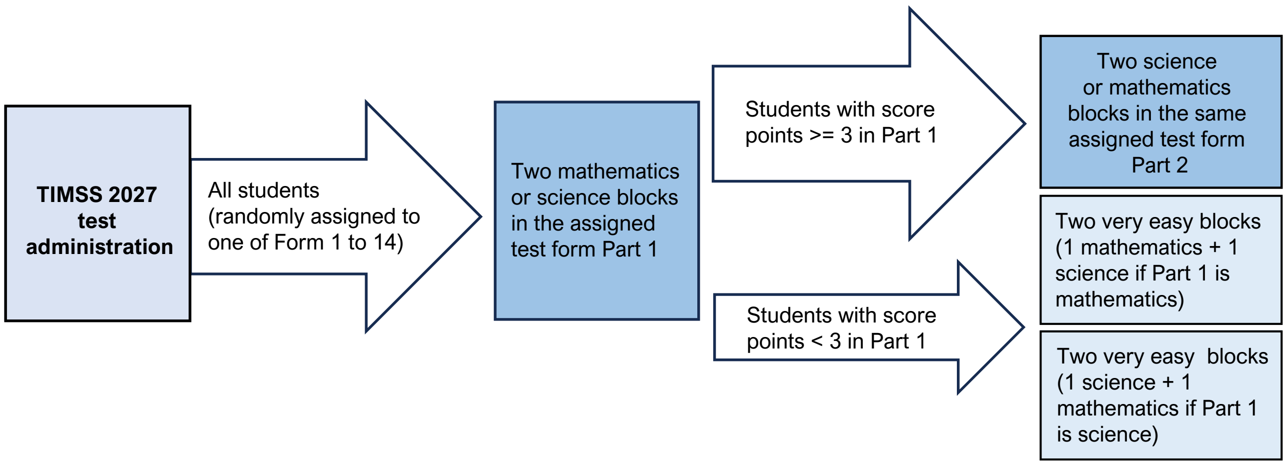
Individual-Level Adaptive Routing

In TIMSS 2027, an individual-level adaptive routing will be implemented for very-low-performing students. Students who demonstrate very low performance on Part 1 of their test form will be routed to two very easy blocks in the second part, instead of receiving the two blocks in Part 2 of their originally assigned form shown in Exhibit 5.

According to this design, students who score fewer than 3 points in Part 1 will be administered one very easy mathematics block and one very easy science block in Part 2. The 3-point threshold is based on responses to the automatically scored items (e.g., multiple-choice, drag-and-drop, number pad items, etc.), regardless of the difficulty of the individual items, or the estimated difficulty of the block. In such cases, the subject sequence in Part 2 depends on which subject was presented first in Part 1. If Part 1 contains mathematics items, then Part 2 begins with a very easy mathematics block, followed by a very easy science block. Conversely, if Part 1 contains science items, then Part 2 starts with a very easy science block, followed by a very easy mathematics block.

The diagram of TIMSS 2027 achievement test form administration is presented in Exhibit 7.

Exhibit 7: TIMSS 2027 Achievement Test Form Administration Diagram



Two very easy mathematics blocks (MVEB1 and MVEB2) and two very easy science blocks (SVEB1 and SVEB2) were constructed for each grade level. These blocks are made up of the easiest items from the existing easy blocks and, like other TIMSS blocks, consist of items drawn from different content and cognitive domains. MVEB1 contains selected items from ME1 and ME2, and MVEB2 contains selected items from ME3, ME4, and ME5; the same pattern is followed for the science blocks. As shown in Exhibit 8, this facilitates matching very easy blocks to Part 1 blocks without overlapping content, ensuring that no student sees the same item twice.

Introducing the individual-level adaptive routing for the students effectively results in an additional 14 forms, shown in Exhibit 8.

Exhibit 8: TIMSS 2027 Forms Assembled with Very Easy Blocks for Individual-Level Adaptive Routing

Assessment Forms	Forms Originally Assigned	Part 1		Part 2	
Form 15	Form 1	SM1	SD1	SVEB2	MVEB2
Form 16	Form 2	MD2	MD3	MVEB2	SVEB2
Form 17	Form 3	SM2	SD2	SVEB2	MVEB2
Form 18	Form 4	MD5	MD1	MVEB2	SVEB2
Form 19	Form 5	SM3	SD3	SVEB1	MVEB1
Form 20	Form 6	MM4	MD4	MVEB1	SVEB1
Form 21	Form 7	SD4	SD5	SVEB1	MVEB1
Form 22	Form 8	ME1	MM1	MVEB2	SVEB2
Form 23	Form 9	SE1	SE2	SVEB2	MVEB2
Form 24	Form 10	ME2	MM2	MVEB2	SVEB2
Form 25	Form 11	SE3	SE5	SVEB1	MVEB1
Form 26	Form 12	ME3	MM3	MVEB1	SVEB1
Form 27	Form 13	SE4	SM4	SVEB1	MVEB1
Form 28	Form 14	ME5	ME4	MVEB1	SVEB1

Student Testing Time

As summarized in Exhibit 9, each student completes one student achievement test form consisting of two parts, followed by a student questionnaire. The individual student response time for the TIMSS 2027 assessment is the same as it has been since TIMSS 2007, including for students who are routed to the two very easy blocks in Part 2.

At the fourth grade, the TIMSS administration consists of two 36-minute sessions, one for each part, and then followed by a 30-minute session for the student questionnaire. At the eighth grade, the administration consists of two 45-minute sessions, followed by a 30-minute session for the student questionnaire. Students are given a short break between sessions.

Exhibit 9: TIMSS 2027 Student Testing Time – Fourth and Eighth Grades

Activity	Fourth Grade	Eighth Grade
Student Achievement Test Form – Part 1	36 minutes	45 minutes
Break		
Student Achievement Test Form – Part 2	36 minutes	45 minutes
Break		
Student Questionnaire	30 minutes	30 minutes

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